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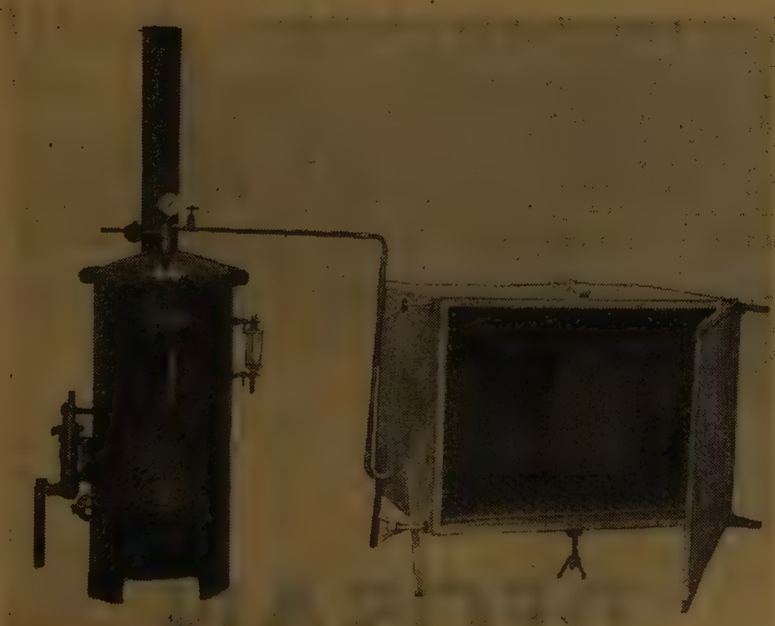

THE
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CONFERENCE ON TROPICAL AND SUB-TROPICAL SOILS

The plans for colonial development which are now being put into effect are intended to increase the productivity of the dependencies in minerals, industries and agriculture. Development of minerals and industry should lead directly to a higher standard of living for the native populations, but this cannot easily be attained without a substantial increase in agricultural productivity. More efficient use of the soil is therefore a vital part of the development plans, and in order to reach this objective it may be necessary to revolutionize the methods of production, as is now being attempted in the East African Groundnut Scheme. But our knowledge of tropical soils is far from sufficient to permit drastic interference with the present native methods of cultivation, inefficient though they are, and the study of tropical soils is therefore of immediate and essential importance.

With this in view, the Colonial Office considered it advisable that a conference on tropical and sub-tropical soils should be held in 1948, and the Commonwealth Bureau of Soil Science undertook to organize this. At first the conference was to be solely on the classification of these soils, in order that a common basis should be found for soil surveys, but as plans developed it became clear that the opportunity should be taken for discussions on urgent problems of soil fertility. Although this made the conference programme a heavy one, the decision to include soil fertility proved very wise, since it made possible exchanges of views between workers in widely differing fields.

Representation was extended beyond the British Commonwealth, and the list of official delegates shows the great importance which other countries place on the study of these soils. Four members came from the United States of America, three from Belgium, four from France, three from Holland, and one from the Food and Agricultural Organization of the United Nations. The British Commonwealth was represented by two delegates from South Africa, two from India, one from Australia, one from New Zealand, one from Palestine, one from Cyprus, ten from East and Central Africa, six from West Africa, two from Malaya, five from the British West Indies, and one from the Anglo-Egyptian Sudan. Fourteen members represented the United Kingdom, including two from the Colonial Office. The conference was opened by Mr. D. R. Rees-Williams, M.P., Under Secretary of State for the Colonies, and the Earl of Listowel presided at an official luncheon given by H.M. Government.

The first six days were spent at Harpenden, where the Rothamsted Experimental Station entertained the delegates, and nine meetings were held for the presentation and discussion of papers. The party then moved to Oxford, where they were guests of Magdalen College for four days, and excursions were made to neighbouring places of scientific interest, in order to give the overseas delegates an insight into methods used in the study of temperate soils. Lyndhurst, in Dorset, was the centre for the last three days of the tour, which were mainly concerned with soil studies relating to re-afforestation. Forestry problems are now being studied in greater detail since large-scale re-afforestation of the less fertile parts of the United Kingdom has been started, and the difficulties of establishing economic trees on land unsuitable for agricultural production are being investigated by soil scientists. Agricultural and forestry research are now being combined in some of the British Dependencies, and this comparatively new branch of soil science will find wide application in colonial development.

Forty-seven papers were submitted for discussion at the meetings in Harpenden, the general grouping being review of tropical and sub-tropical soils, soil classification, fertility problems and soil erosion and miscellaneous problems. Each paper was summarized by its author at a morning session of the conference, and the groups of papers were discussed at evening meetings. The findings of the conference were drafted by two small committees, one on soil classification and one on fertility problems, and their reports were discussed, amended and adopted as resolutions at the final meeting.

The discussions on soil classification in relation to soil surveys showed clearly that much more information on the genesis and morphology of tropical and sub-tropical soils

is required before a satisfactory working classification can be drawn up. The resolutions of the conference emphasize the urgent need for greatly increased staffs for soil surveys, and point out that greater facilities should be made available for the study of the more fundamental properties of these soils, in order that classification and surveys may be put on a sound basis. On account of the comparative lack of knowledge of tropical and sub-tropical soils, the conference was unable to make definite recommendations regarding their classification, and it was suggested that a standing committee should be appointed in the United Kingdom, to whom information and samples could be sent for correlation, since there are at present insufficient facilities for the application of existing knowledge. This central committee would define methods of mapping, advise on methods of analysis and on the use of aerial photographs; it would also keep under review the definitions of those Great Soil Groups which include tropical and sub-tropical soils. The conference agreed that progress would be slow unless arrangements were made for the collection and correlation of information, but it was realized that the regional research organizations which are now being set up in the British tropical dependencies would greatly assist in this work. Uniformity of methods of soil sampling and analysis were also considered desirable, in order to permit better comparison between observations from different countries. Even with regional co-ordination it would not be easy to collate information in different methods, and standards continue to be used.

Resolutions were also passed by the conference regarding the study of soil fertility in the tropics. The first point made was that a considerable amount of useful knowledge already exists in the records of territorial departments of agriculture, and the recommendation was made that means should be sought by which this knowledge should be more generally known and applied in native agricultural practice. While it was realized that district agricultural officers have little time for the collection and presentation of their knowledge and experience, it was felt that progress is handicapped when useful data and observations lie buried in departmental files. It was pointed out, however, that, even allowing for this, there is little prospect of any real advance towards efficient stable systems of farming without large additions to the number of specialist and technical officers. Experience in temperate regions has shown repeatedly that major agricultural advances have to await the introduction of new techniques developed from fundamental and technological research. Hitherto very little research has been undertaken in the basic principles underlying native agricultural methods in relation to local soils and climates. Improved systems of husbandry will require greater expenditure in effort and materials than the old methods. Machines and fertilizers will have to be used far more widely, and, at least in the early stages, it will be necessary to subsidize their use.

Fertility studies are receiving high priority in plans for research in tropical agriculture, but conclusive results cannot be expected in a short time. Local variations within a soil type and annual variations of climate render the results obtained from one set of field trials of doubtful value, and frequent repetition on a wide range of sites is necessary before reliable conclusions can be drawn. But the results of field trials are greatly enhanced if they can be explained by laboratory investigations, and thus long-range theoretical studies form an indispensable complement to fertility trials in the field. Co-ordination and correlation are essential in order to obtain the maximum value from field and laboratory investigations, and the conference recommended that in each of the major regions of the tropical and sub-tropical dependencies there should be set up a Soil Fertility Committee to be responsible for the general planning and conduct of field experiments and related laboratory investigations on soil fertility questions, and for the summarizing of results of both past and current work. This committee would include agricultural officers from the territorial departments of agriculture as well as research officers. It was suggested that the main purpose of the field experiments should be the analysis of native practice and of alternative systems, including the use of live stock, so as to discover their underlying principles and mechanisms. Laboratory investigations should also cover a wide field, including soil moisture, factors controlling the availability and uptake of plant nutrients, particularly phosphate, foliar diagnosis, soil organic matter and soil structure, and the erodibility of soils. Research is also needed in association with forestry departments on the use of trees and shrubs for soil regeneration and for producing leaves

for use as fodder, litter, mulching, or manuring, either directly or in compost. Investigations were also suggested on the biology of termites in relation to damage to crops and effects on soil fertility and soil formation. It was further suggested that the study of native agricultural methods should be supplemented by anthropological research, to discover new facts about agricultural methods meriting examination, to find some of the less immediately obvious grounds for the reluctance of natives to adopt new ways, and to investigate some of the social implications of introducing new systems of husbandry.

These two sets of resolutions have in common the cry for more staff and facilities, all of which have to be paid by the taxpayer, whose comment may be that he sees little hope of getting a return for the extra expenditure during his lifetime. But farming is a long-term investment, and agricultural research must aim at making the best possible use of the soil over a long period of years. Scientific methods which produce quick profits may render the soil useless in time, and it is only by following a new technique over a decade that its true effect on the soil can be judged. On the other hand, farmers can benefit directly from fertility investigations so long as they continue to keep up with the progress of the work and are prepared to alter their ideas and methods as more information becomes available. Startling discoveries must be viewed with caution, and new techniques may prove disastrous if they are applied in farming practice before they have been tested thoroughly on the experimental stage. The recent agricultural improvements in temperate regions, in spite of centuries of experience and progress, have been made possible only by long-term field experiments based on intensive studies of the soil, and it seems clear that real progress in tropical agriculture cannot be made until we know much more about the properties and behaviour of tropical soils.

D.W.D.

AS OTHERS SEE US: PROSPECTS IN KENYA

By Clyde Higgs

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I had visualized Kenya as a land with all the assets of Britain coupled with those of the tropics. The result would have been a farmers' paradise. In fact, it appears to have a few advantages that we do not possess, and numerous difficulties outside our experience, particularly in cattle farming. To all the diseases that we know so well are added many unheard of in this country. Some are kept in bounds by treatment, but the native animals, if they succeed in gaining immunity by infection, lead a hungry and sordid existence.

Kenya is two and a half times as big as the British Isles, but two-thirds of it is semi-desert. The native reserves occupy nearly seventy per cent of the remaining area, and the forest reserves and lakes another twenty per cent. The balance of some eight and a quarter million acres is available for European settlers. Most of this land is four thousand feet above sea-level. European conditions are found at twice that height, but the rarity of the air impedes visitors' movements and forces residents to make regular visits to lower altitudes. Three thousand farmers share the available land, apart from tea, coffee and sisal estates. Gone are the happy days when a 20,000-acre ranch could be bought at ten shillings an acre; to-day many useful farms in the vicinity of Nairobi are changing hands at £50 an acre and more. Some of the early settlers still occupy large areas, and can make an ample living by farming only part of their estates.

Everywhere in the tropics water is the first consideration, and one estate I visited has been converted in twenty years from useless bush to a profitable self-sufficient dairy farm producing milk of a higher standard than our average, simply by the sinking of bore-holes and the making of dams to conserve all surface water. The milking herd contains over one thousand cows, all of which are hand-milked in open-air bails, sixteen cows to a man. Every cow is washed and her yield recorded at each milking; they are known by such local names as Mombasa Bus, Nairobi Express and Sunday Half-holiday. Artificial insemination has been developed on the farm, not at a central station, to combat disease. The cattle are of native breeds improved by European Ayrshire blood; some of them have now become too much Ayrshire. The first cross gives the best results, although I believe more could be done to improve the native breeds, particularly at low altitudes. At the other end of the scale I visited small farms, intensively cultivated and carrying pure-bred cattle that would do credit to any English farm. But the spectre of disease frightens owners: foot-and-mouth is rampant, and breeding difficulties arise in spite of precautions.

Leys with limited indigenous grasses are gaining ground, and lucerne, when irrigated, produces fantastic crops. Hay made on the traditional lines is of poorer quality than ours, so that ricks are left unfenced because the cattle will not trouble about them until forced by hunger to do so. Silage would be even more popular, if the common difficulties of collection could be solved. Farm labour at a shilling a day, with food and housing, sounds cheap, but it takes seven Africans to do the work of one European. Efficiency in labour management is more vital than academic agricultural knowledge. There is a real dearth of machinery. I met one farmer who had to cultivate five hundred acres of land for wheat with one light wheeled tractor.

There is room, rapidly diminishing, for keen young men with farming knowledge and adequate capital—at least £10,000. They can gain some knowledge of conditions at the excellent Egerton School of Agriculture where the demonstration farm makes a handsome profit; the curriculum could be studied with advantage by our farm institutes. There is accommodation also for the wives and families of students, who have an opportunity to learn their responsibilities in a settler's life. Later, a few months on an established farm would be an advantage for the newcomer before taking over his own holding. Should this be a ready-made one, competition for it will be keen and there may be traps for the unwary, such as a river that disappears in the dry season. Mixed farming is safest, and a thousand acres are needed to make a reasonable living, for some will be unsuitable for

cultivation and ten to twenty acres to a cow is the average figure.

The Government-assisted scheme for selected settlers with a maximum of £1,500 is in abeyance, no more capital being available until there are returns from that already invested. After careful vetting, candidates are provided with land free of rent for five years, at the end of which period they can continue as tenants or purchase their holdings. I met a number of these settlers and all of them were satisfied with the job of clearing, building a house, making roads, providing water and all the other work that goes to turn bush into farmland. Their progress was amazing. One told me that he was clearing thorn-bush and levelling gigantic ant-hills with native labour at fifteen shillings an acre. But hard work interspersed with hard play is needed to farm out there as it is at home. Young men would shudder at doing a normal Kenya day in England; if they did it, the improvement in the standard of our farming would lessen considerably the urge to emigrate.

COMMENTS ON A PLANT BREEDERS INFORMAL CONFERENCE

By P. J. Greenway, Systematic Botanist, E.A.A.R. Institute, Amani, Tanganyika

(Received for publication on 4th October, 1948)

An informal meeting on plant genetics was held at the School of Agriculture (New Building), Downing Street, Cambridge, on the 24th and 25th June, 1948, which various official delegates from Great Britain and the Commonwealth attended.

The meetings opened with a review of the activities of the Commonwealth Bureau of Plant Breeding and Genetics by Dr. P. S. Hudson and Mr. R. H. Richens. The delegates then reviewed the plant breeding work that was going on in their spheres of the Commonwealth.

Dr. Hudson reported on a meeting held at Washington in April, 1948, between F.A.O., the Commonwealth Agricultural Bureaux, the United States Department of Agriculture and other bodies on genetic stocks.

Discussions followed during the meetings on the collection, maintenance and distribution of genetic material, and on the organization of breeding work within the Commonwealth, etc.

As a taxanomic botanist, I attended as an observer only, as I am not a plant breeder. Judging from the accounts of the various delegates to the meeting it seemed to me that the Dominions, Great Britain and Northern Ireland are well off for plant breeders, whilst we of the colonies and protectorates are sadly lacking in such people. As an example, in the six East African territories and protectorates there are only about two plant breeders employed by the East African governments.

Should East Africa ever be in that happy position of having an adequate number of plant breeders, it seemed to me that whilst a great deal of genetical work has been done on the more important tropical economic crops, perhaps better known as cash crops, such as cotton, sugar cane and maize, the lesser crop plants have been neglected and should be more closely studied by plant breeders.

If the nutrition and well-being of the African peoples is to be considered, it is the food plants that play an important part in the diet of the African that should receive more attention than they have done in the past. Of these plants I am aware that, amongst the grains, Sorghums are being studied in the United States and Australia, and that wheat selections and breeding were being done in Kenya before the war, but there are other grains such as Bulrush or pearl millets (*Pennisetum typhoides*), finger millet (*Eleusine coracana*), rice (*Oryza sativa*), and rye (*secale* spp.), which require study in tropical Africa.

Of the more important pulses the cowpea (*Vigna ungiuculata*), french or kidney bean (*Phaseolus vulgaris*), hyacinth, Bonavista or Indian butter bean (*Dolichos lablab*), the pea (*Pisum sativum*) and pigeon pea (*Cajanus cajan*) all need attention from the plant breeder.

Of the root crops Cassava, sweet potato and the European potato are being studied. There are many fruits both cultivated and wild that are eaten by the African. In the

solanums there are a number whose fruits are used as a vegetable, but we know little about these, not even their correct botanical identities, they are important items of the Africans' diet as they are cultivated in various parts of East Africa.

Various leaves are used as pot-herbs in the diet of the African, there are those of perennials such as in the trees and shrubs, the Baobab (*Adansonia digitata*), Ceara Rubber (*Manihot glaziovii*) and Cassava (*Manihot utilissima*) and the leaves of the sweet potato (*Ipomoea batatas*), these are commonly used. Trees and shrubs are not exactly suited for breeding work owing to the time factor, but amongst the annual herbs whose leaves are eaten the more important are the french bean (*Phaseolus vulgaris*), the bastard mustard (*Gynandropsis gynandra*), spider flower (*Cleome* spp.) and a group of *Amaranthus* spp. as represented by love-lies-bleeding. All these are of importance in the nutrition and health of the African and they could with advantage receive attention from the plant breeder. I have not mentioned temperate vegetables as they are a study in themselves and can only be grown in limited areas in tropical Africa.

Should the improvement of such food plants as I have indicated be undertaken by plant breeders in East Africa, their task will not be easy. They will have many interesting and exciting problems.

We have an altitudinal range from sea level to over 19,000 feet with corresponding climates and an African population that lives between sea level and about 9,000 feet with the greatest number between 3,000 and 5,000 feet.

We not only need heavier yields in our crops but resistance to insect and bird attacks as well as diseases. Longer-keeping qualities are required for storage against famine which still stalks the land. In conclusion I will mention that processing and cooking qualities should also be considered when breeding food plants. For instance, it is not much use the administrator, agricultural officer or welfare worker advocating to an African population a grain as a food if it is only suitable for beer-making, as is the case in some varieties of Sorghums, or recommending a pulse which requires hours of boiling before it is edible in areas where cow dung is the only fuel obtainable for cooking.

SOME PROBLEMS OF THE CHAGGA ON KILIMANJARO

By R. J. M. Swynnerton, M.C., Agricultural Officer, Tanganyika

(*Received for publication on 9th August*, 1948)

One of Africa's major problems economically, socially and politically is overcrowding in restricted areas of land grossly underpopulated as a whole. Provided it is not accompanied by its attendant evil of soil erosion, such overcrowding can for a time be met with advantage by the intensification of agricultural and animal husbandry, although these practices are better designed to raise the standard of living of a stable population than to maintain an expanding population at subsistence level. Movements of population to underdeveloped areas are, excluding traditional reasons, restricted by climate, soils, health, tsetse fly and water supplies. Mountain dwellers are particularly affected as the population expands more rapidly under the healthy climate; the good lands are rapidly occupied while the effects of cultivation and stock on the steep slopes soon reduce fertility through soil erosion. The descent to the plains of the surplus population, their only outlet, presents an unaccustomed struggle with disease, a harsher climate with uncertain food and water supplies, the influence of tsetse fly on stock keeping, and changes, often for the worse, in soil conditions and nutrition. This account is designed to show how the problems affect one small community, the Chagga, living on the fertile slopes of Mount Kilimanjaro in the Moshi District of the Northern Province of Tanganyika.

Preliminary Investigations and Development

Living in a healthy climate, with food and income generally assured, the Chagga have developed as a virile tribe with a firm desire for progress. This has been met by the development of a strong union of co-operative societies based on their prosperous coffee industry and by popular representation in their tribal councils. The increasing density of population has given rise to a series of investigations, the recommendations of which, it is hoped, will provide the foundation of post-war development. In 1930 Griffiths [8] reported on their land tenure and irrigation systems; in 1934 Teale and Gillman [15] dealt comprehensively with the control of water; in 1947 the Arusha-Moshi Lands Commission [16] made exhaustive recommendations on redistribution of alienated and native lands and on the development of the underpopulated lowlands, while a detailed survey of the incidence of tsetse fly in the Moshi district has recently been completed by A. G. Robertson, Tsetse Research Entomologist. Meantime, during the war and subsequently, the native authorities have started by increased taxation to finance re-afforestation, education, development and administration. Within its province, and having due regard to safeguarding the banana and food supplies and the natural resources of the district, the Moshi Native Coffee Board has embarked upon a progressive development programme financed from a levy on the native coffee crop, the levy giving an annual income of about £30,000 for the first three years of operation. This has enabled the Board, as recorded in their annual reports [1], to maintain an active staff of inspectors and instructors for the improvement of plantation sanitation, cultivation and preparation of coffee. It has also supplied the means for a programme to instal water supplies on eastern Kilimanjaro; for a school for training staff, propagators and progressive growers; for housing for its staff, the erection and expansion of coffee-curing works in Moshi in conjunction with the European growers represented by the Tanganyika Coffee Growers' Association, the publication of a book in English and Kiswahili entitled *All About KNCU Coffee* [14] covering the history, cultivation, preparation, marketing and the pests and diseases of Chagga coffee, and for a scheme to replace the twelve million coffee trees of the Chagga during the next twenty years by high yielding seedling and clonal selections from the Coffee Research Station at Lyamungu on Kilimanjaro. Preliminary work on the development of ten propagation centres of 20 acres each, including the erection of camps, building and propagating frames, is in hand though there will be a time lag in the distribution of planting material pending the receipt of adequate supplies of parent trees from the Coffee Research Station and their multiplication at the Board's nurseries. The coffee

industry is, therefore, being dealt with vigorously and, at least so long as a reasonable return to the grower is assured, it is not an outstanding problem. However, to meet a future recess in prices, the programme aims at raising the general level of coffee yields two or three fold by improving cultivation and preparation and by replacing the present coffee trees, which yield on the average 3 cwt. of coffee per acre, by selected trees which, at least under Coffee Research Station conditions, yield up to 15 cwt. per acre.

Climate and Topography

Climate and topography have moulded the development of Chagga society and will influence greatly the tribe's future expansion. The geology, topography and climate of Kilimanjaro have been described by Teale and Gillman [15] so they need only be summarized here as an introduction to the agricultural problems of the area. Teale and Gillman describe how "Moshi and Arusha districts form a region where rapid variation of all the geographical elements is exhibited within remarkably short distances. Thus in a few miles there is a transition from plain to precipitous slope, from desert climate to humid tropical and temperate conditions and, if one includes the highest region, outside the inhabited zones, to arctic desert and polar ice cap. From the geological point of view there is a wide range of volcanic rocks of varying chemical and mineral constitution. The reaction of soil-forming processes to wide gradations of climate on such a varied foundation has clearly resulted in a diversity of soil texture, character and composition, which introduces many apparent anomalies in the changing conditions for, and practices of, agriculture and irrigation.

"Not only does the rainfall vary within a few miles from semi-desert conditions to those of high rain forest precipitation, but the actual seasonal distribution is marked off by sharp weather partings. Extremes of all kinds meet in a vertical and horizontal plane. Superimposed on this very checkered natural basis is a highly developed native agricultural and irrigation system with long established customs and laws". This has recently been invaded by European enterprise, first under a determined German policy, later interrupted by the war period of instability, and now under British control.

With a mean annual rainfall of 41 inches at Moshi, that at Arusha Chini nine miles to the south is 18 inches, and at Kibosho Mission six miles to the north it is 90 inches.

Teale and Gillman emphasize that "Of no less importance is the undeniable fact that although the cultivation zone enjoys a distinctly more humid climate—that irregularity of rainfall, both as regards time and volume, which one generally associates with a semi-arid region, does unfortunately penetrate into the more humid belt".

In general, the soils of the cultivation zone on Kilimanjaro are chocolate brown loams, rich in plant nutrients, derived from the lava flows "Gradually built up on a southerly sloping floor of crystalline schist by successive phases of volcanic activity from the major triple composite massif of Kilimanjaro, composed of the eroded masses of Shira and Mawenzi, covered and dominated by the great ice capped dome of Kibo". The zone of minor cones forming the divide between Rombo and Vunjo, the Kirua ridge in the centre and the marked high ground between Machame and Kibongoto leave roughly triangular hollows of ground between of "Relatively gentler topography with conditions most suitable for human occupation". The area is well watered due to the forest collecting the great moisture supplies of Kilimanjaro which result in numerous permanent streams and springs, whereas the large lowland springs are formed by water which has percolated through volcanic faults of varying permeability. The substantial flow gushing from these is lost to the upper cultivation zone and commands but a small proportion of the lowlands, though Teale and Gillman see good possibilities for boring for water for domestic and pastoral use.

The principal zones of interest to us are the protected rain forest lying between the 6,000 and the 9,000 ft. contours, the fertile highland home of the Chagga lying between 3,000 and 6,000 ft., the land lying between 3,500 and 5,000 ft. being the most productive of bananas and coffee. The less healthy lowlands were shunned by the Chagga in days gone by on account of the depredations of the Masai and the incidence of tsetse fly. While the gradation in rainfall with altitude has been noted, excluding the wholly alienated areas of Sanya Juu and Ngare Nairobi, precipitation is greater in the south-west than the east. In the eastern Rombo division the rainfall in the short rainy

season (October to February) is more pronounced, though very erratic, so that two rainfall crops may be raised a year. On the southern slopes three-quarters of the year's rain falls in the long rainy period of March to July and, except at the highest altitudes, out of season cultivation must be dependent on irrigation. Table I summarizes rainfall statistics to the end of 1946 kindly supplied by the B.E.A. Meteorological Service.

It is in the healthy highland belt, sixty miles long and five to eight miles wide that the Chagga tribe has risen to its present degree of prosperity with a congested population based on the staple food crop, the banana, and the substantial income from coffee cultivation. Yields of bananas in the second half of the year are very dependent on the short rains, and the uncertainty and aridity of the climate has just been noted. It has become increasingly evident in the recent dry years that the population has outstripped the supplies of banana in any but the most favourable seasons. The surplus rising generation, against the background of the productive highlands, must face with uncertainty the prospect of descending to the semi-arid climate of the plains. Except along the banks of rivers and irrigation channels at Kahe and Arusha Chini even the most drought resistant varieties of bananas will give but poor results without irrigation and, weakened by the hot dry seasons in these areas, will be more prone to succumb to the recently recorded banana borer (*Cosmopolites sordidus*). Under irrigation many of the lowland alluvial soils must be treated with the greatest respect and ample provision made for drainage to counter the serious alkalinity that is liable to occur in those areas. The rainfall in the highlands affects seasonal planting. Curry [4] records how finger millet (*Eleusine coracana* Gaertn.) depends on irrigation in these areas because it must be planted after the main rains in order to ripen into the drier, warmer weather. Beans and root crops too in the banana zone are planted as the main rains decrease, the bean blossom being particularly affected by rain. At the higher altitudes crops, including maize, are planted from August onwards so that they benefit from the short rains and ripen into the hot season. At Rongai, maize planted with short rains at 6,000 ft. takes eight months to harvest but yields a heavy crop.

THE ECOLOGY OF THE MOUNTAIN CHAGGA

The Chagga have been pinned down to individual holdings to a greater degree than most tribes in East Africa by dependence on their orchard crops of banana and coffee. Perhaps the most encouraging feature of the Chagga problem is that it has been brought about by improved agricultural conditions and education and by a rising prosperity and not by the conditions, soil erosion and over-stocking which aggravate so many tribes. The fact that they have been pinned to the land has obliged them to maintain and to try to improve soil fertility, using every means to hand, the manuring of banana plantations being a regular practice. Apart from losses due to soil erosion, leaching in the high rainfall areas or harmful irrigation, probably more nutrients are imported into the holdings as fodder for live stock (grass, weeds, stover from maize, beans and finger millet from lowland cultivations, tree loppings for goats, bedding, wood ash from firewood) and food for the family (maize, finger millet and pulses from lowland fields) than is removed in the export crop, coffee.

From time immemorial cattle have been stalled in the two southern divisions of Kilimanjaro, Hai and Vunjo, a practice originating, it is thought, through fear of tsetse infection when grazing in the plains and Masai raids in the period before European occupation. Improved health has made many of the Chagga reluctant to live in the lowlands. As a result of the recent occupation of all suitable land in the highlands the grazing land there

TABLE I

SUMMARY OF RECORDS FROM RAINFALL STATIONS—MOSHI DISTRICT

STATION	Average of Stations	Mean for five-month period March—July		Oct.—Feb.		Mean Annual Total
		in.	%	in.	%	in.
Short-rains Areas	9	14·28	48	14·46	49	29·57
Southern Dry Lowlands	4	15·20	69	5·71	26	21·98
Southern Maize Lands	2	31·47	75	9·16	22	42·02
Southern Bananas Highlands	7	49·84	73	14·46	21	67·96

has been severely curtailed, though cattle may be seen for short periods in the day taking the air on the small greens before being returned to their dark stalls. The milk yields of these pygmy animals are low, while the method of their stalling may well contribute to the high incidence of tuberculosis among humans on Kilimanjaro. It is clear that such a system could not have been developed without the banana, the stems and leaves and peelings of which are the principal fodder and water supply of the live stock, and the bunches the staple ingredient of the Chagga's diet and his beer. Surplus bunches, now less frequent and seasonal, are sold at the innumerable markets so dear to Chagga women, are fed to live stock or may be preserved by drying. In addition, the huts in the area west of Moshi, characteristic squat beehives, are dependent on banana leaves for their thatch, while eastwards the larger *Msonge* type of hut is thatched with grass from the lowlands. In fact, banana stems and leaves are put to such good use that it is impossible under present conditions to implement the recommendations of the Coffee Research Station [7], namely, to mulch banana and coffee orchards to improve soil conditions and yields. This is so important that the Native Coffee Board is insisting on the greater use of bananas as shade for coffee.

Under these circumstances a very close association exists between the Chagga and his surroundings. Nothing grows there that is not utilized, nor does he or his wife return empty-handed from the lowlands. All the manure and refuse is returned to the banana plantation in a regular rotation, being piled up against the banana stools. Among the bananas and depending on their spacing, are grown many other crops such as beans, yams, maize, cassava and, not least, coffee. The coffee in parchment represents the main export of fertility from the mountain area, though small quantities of other crops grown in the holdings are sold or exchanged on the local produce markets when there is a surplus or when there is a need for ready cash, or for food such as milk, beans, finger millet, maize or roots. Weeds, collected daily from the gardens, from the hedgerows or from the nearby plots of annual cultivation of such crops as sweet potatoes, yams, *Dioscorea* or taro, *Colocasia* or finger millet, are fed to the live stock. Clippings from the hedges and the pollarded branches from trees are also used for feeding live stock, while both hedges and trees are used to the fullest extent for providing tying materials, fibres, withies, poles, timber and fuel. The leaf fall also adds nutrients and protection to the soil.

The upright *Dracaena steudneri* is the commonest and traditional boundary hedge. *Toddalia asiatica* is a very useful and neat hedge for layering, its long rambling branches being easily trained. Mauritius Thorn, *Ceasalpinia sepiaria*, on the other hand, requires constant attention to prevent it from covering a great width of ground but it also gives doughty protection. Other hedges frequently met with include three species of *Commiphora; Senecio multicorymbosus* (a giant groundsel); *Aloe volkensii;* a fleshy Euphorbia, *Synadenium* sp.; *Plectanthrus umbrosus;* the mulberry, *Morus indica; Cassia bicapsularis* and Elephant Grass. The clippings from all these, even the younger shoots of the thorniest, give fodder for goats and the quantities used must be appreciable since propaganda for the replacement of such hedges by Elephant Grass in less shady places has met with but limited response. The planting of Elephant Grass to protect contour banks is not favoured by the Chagga, who consider that the root system of this grass interferes with crop yields for several feet on either side.

Some of the indigenous trees still exist in the holdings and many others have been planted in the hedges or as shade for coffee and, to a lesser extent, for bananas. Space here allows for the naming of but a few of the species among the considerable assortment of trees grown by the Chagga for fuel, building materials, poles, banana props, carved water containers, beehives, barrels, bowls, plates and spoons and for goat fodder as well as bedding material. The many uses of the common ones grown as shade trees among coffee or bananas or as shelter belts in the hedgerows have been described in *All About KNCU Coffee*. They are *Albizzia maranguensis, A. brachycalyx, Cordia holstii, Rauvolfia inebrians, Cassia didymobotrya, Trema guineensis,* and *Grevillea robusta.* Cypresses are commonly planted while, unlike Bukoba, *Markhamia platycalyx* is less commonly planted than it merits. Among the other common trees grown in the hedges, many pollarded, some coppiced, for goat fodder or for withies, are *Turraea robusta, Bridelia micrantha, Olea chrysophylla, Stegathus welwitchii, Eribotrya japonica, Pygeum africanum* and *Alangium chinensis.* Two trees that attract attention as one goes round the

mountain are the "baraza" fig, *Ficus vogelii*, shading the meeting places, and a flat-topped acacia, *Acacia lahai*, that grows up the ravines of the south-east and eastern slopes and spreads out above 5,000 ft. into the cultivated fringe of the forest at Rombo.

The very close interdependence of the Chagga and his surroundings becomes more evident the more it is studied and should be subjected to the closest investigation lest it be disrupted by external and experimental influences without gain. Increase in the intensity of production must include the banana and coffee orchard and annual crops, live stock, the grasses, the hedgerows, the trees, the weeds, utilization of the closed ravines, irrigation and the lowland annual crop lands and the live stock carrying capacity and manurial production of the whole system.

The Dense Highland Population

While many tribes have yet to reach the limit of their individual productivity by increased diligence and intensified farming, a tribe as far advanced as the Chagga culturally and agriculturally must either overcome the handicap of manual labour to enable it to raise its social standards or else let some aspect of its complex economy slide by endangering food supplies, by a loss in income or by a decrease in the number of live stock without which the maintenance of their present standards could not have been achieved. In the thirty years of British administration an unparalleled expansion in cultivation has taken place; between the wars when Major Dundas (now Sir Charles) laid the foundations of the coffee industry, and during World War II when the vast expansion in the lowlands of annual crop cultivation, especially maize, filled the vacant spaces of the highlands and the less arid areas in the lowlands. With strict supervision by the Agricultural Department and the chiefs of their soil conservation measures and cultivations and under the guidance of Mr. A. L. B. Bennett as the supervising manager of their progressive Kilimanjaro Native Co-operative Union [2] their production of coffee was advanced from below 1,000 tons of parchment coffee before 1931/32 to 4,250 tons by 1947/48, valued at some £300,000 to the growers after deducting all costs of levies and marketing.

The expansion in the population and an increase in number of coffee growers (30,000 in 1947) have led to such congestion in the population and such intensive cultivation (in the areas best suited to the health of the tribe and for the growing of coffee) that both the future of the people and of coffee have had to be closely surveyed. The Moshi Native Coffee Board has concluded that, if it is not to endanger the food supplies of the people, future expansion of coffee production must no longer be achieved by increasing the area or number of trees planted but by raising yields per acre. The absorption of large areas of land for maize cultivation in recent years has been noted. In addition, a substantial area is planted annually to onions to provide an income for those Chagga living in the lower villages too marginal for coffee on account of drought and white coffee stem borer. The recent average onion production (the cultivation of which has recently been described in this Journal [13]) of 1,000 tons a year is worth £15,000 to the growers.

These then are the conditions which the expanding population and its increasing energies have brought about. The occupation of the belt, so climatically suited to their development along the southern and eastern slopes of Kilimanjaro between the 3,000 and the 6,000 ft. contours was completed about 1938, shortly before World War II, which held up plans for investigating the best means of intensifying productivity in the occupied highlands and the orderly expansion into the sparsely populated semi-arid lowlands. Based on a population of 156,000, 12½ per cent lower than the figure accepted by the Wilson Report, Table II gives the population density on Kilimanjaro in 1946, as estimated by Elliott and Swynnerton [6].

TABLE II

Population Density on Kilimanjaro

Division	Total area	Area alienated	Chagga population per sq. mile	Acres available per family
	acres	*acres*		
Rombo ..	117,000	573	244	9·2
Vunjo ..	96,500	11,033	288	7·7
Hai ..	160,000	33,222	343	6·5
Highlands	373,500	44,828	295	7·6
Lowlands	194,000	53,317	58	40·7

The 20,171 acres of ravines and steep slopes estimated by Griffiths [8] as unsuited for cultivation are included in these figures, and also the 105,000 acres of lowland grassland. In the most densely populated chiefdoms of Kibosho (756 per square mile), Marangu (547) and Uru

(495), the land alienated to non-natives amounts to as much as 36, 20 and 23 per cent respectively of the total area.

With the increasing pressure of population, expansion into the sparsely populated lowlands, now inhabited by alien tribes except at Kahe and Arusha Chini, is hindered by several factors, such as marginal or inadequate rainfall, lack of irrigation to supplement irregular rainfall (though this can and will be developed, especially if highland irrigation is rationalized and the Pangani Falls hydro-electric scheme does not prevent such development) and tsetse fly (the retreat of which can be speeded by settlement and cultivation schemes). Other adverse factors are the high alkalinity in some alluvial flats, especially near the Kikuletwa River, inadequate investigation into suitable crops and animal husbandry for these areas, and, most important of all, the actual initiation by Government of a scheme to clear water, and settle as well as cultivate mechanically the vacant or suitable areas. The development of these lowlands is the principal remedy recommended by the Wilson Report which resuscitates and broadens the 1938 Himo-Rau expansion scheme to relieve the congestion in the highlands. Even if this development should take the old-fashioned form of a settlement scheme, as such the people of the highlands will become increasingly dependent on the lowlands for their supplies of food, as well as fodder and concentrates for live stock such as cotton seed, groundnut cake or lucerne hay, none of which are used at present.

Land Tenure

Griffiths [8] records that the Chagga tribe comprises some 700 clans originating from the alien tribes of the Teita, Sambaa, Kamba, Kahe and Masai who absorbed the original forest tribe, the "Wakonyingo", some 300 years ago and that clan rule was stabilized about 200 years ago. Even to-day the clan elders control the use of water and exert profound influence on the Chiefs in land matters and this is undoubtedly the reason for the strong opposition to the registration of holdings recommended by Griffiths. In the early days, when land was abundant, large holdings were allotted to or were secured by clans and individuals. These have subsequently become subdivided amongst their descendants and dependants so that the greater part of the land is now in beneficial use.

Chagga secretiveness and suspicion of the intentions of Government have not permitted a detailed agricultural survey of Chaggaland to determine accurately cropping systems, yields, acreages, food requirements of humans and live stock, etc., so that many of the details of our information can but be intelligent surmise. The principal recorders of the system of land tenure on Kilimanjaro are Griffiths [8] and Johnston [10], whilst the following extracts are culled from our latest authority, the Wilson Report [16].

"The Chagga system is based primarily on the acquisition as of right of a stated portion of the tribal lands by each young man of the tribe on his coming of age. The extent of this portion, which is called a *Kihamba* (pl. *Vihamba*) varies according to the scarcity or otherwise of suitable land. In some parts of Rombo it may be as much as ten acres or even more, in other places, such as Kibosho, as little as one acre. The applicant receives his *kihamba* at the hands of his chief (the boundaries being marked with the traditional *Dracaena* fence) on payment of a customary present according to his means. In some areas the clan elders exercise a considerable influence on the chief's distribution of *kihamba* land. A man on marrying a second or subsequent wife can come along and demand another *kihamba*. Each *kihamba* technically is occupied by the wife and descends to her male issue, if any, on the death of her husband.

"There he builds his beehive hut, plants his banana grove to provide his staple food and finger millet to brew his favourite drink, plants also his patch of coffee trees to bring in a little ready money, and tends his three or four stall-fed cattle in their almost constant immurement. That is his homestead, built in the Chagga homeland, the centre of his economic and social life. But it is not only land he farms. It is the Chagga custom for a man to have, in addition to his *kihamba* land, a garden on the lower slopes of the mountain on land not yet taken on for *vihamba*. There he cultivates annual crops, such as maize, which do not grow well in the climatic conditions of the upper lands. These *garden* plots are given out annually and the grant confers no right to permanent occupation. It can be withdrawn by the chief as soon as the crop is reaped and often is, when the land is required for division into *vihamba*. The tenure conferred by a grant of *kihamba* land, on the other hand, is virtually freehold in native eyes,

though there still exists a measure of customary control over it by the clan elders in certain circumstances. But this is tending to disappear. In the old days, for example, a man could not sell his *kihamba*; now he can do so freely without asking permission of his chief or anybody else. He can even let it lie uncultivated if he wishes. So with the passing of the old customary control and the advent of cash crops for which there is a ready market, the possession of land has taken on a novel, exciting value.

"In the old days . . . . wealth had obligations as well as rights and of itself brought little personal material advantage, though of course it carried with it power and influence and was therefore sought after by the ambitious. But now all that is changed. A subsistence economy has given place to an exchange economy. In the circumstances it is not surprising that more of the very shrewd and forthcoming Chagga people than formerly are willing to taken on themselves the burden of wealth. The only obvious way of acquiring it, in the present economic set-up, is by the cultivation of cash crops on as extensive a scale as possible. Unfortunately, to grow crops one must have land and land on Kilimanjaro is in short supply. There was strong ground for thinking that those who had got hold of excessive portions of *kihamba* land were using them for purposes other than those of residence and the growth mainly of subsistence crops, which are the usual customary uses of *kihamba* lands; in other words, that this extra land is being used for growing coffee, the great source of native wealth on Mount Kilimanjaro."

Johnston [10] records cases of *vihamba* changing hands for prices as high as Sh. 1,400 for a three-acre *kihamba* with coffee, bananas and a stone house. In 1930 Griffiths recommended land registration in order to keep a check on the acquisition of land and to facilitate the investigation of the endless land disputes. In the old days land was parcelled out in all the chiefdoms in the large blocks of ten acres or more as is the last remaining portion of northern Rombo to-day. The Chagga contend, and this is one of the main reasons they have refused to accept land registration, that all the large estates are in beneficial occupation, feeding and giving employment to relatives and landless men. While scaling down is obviously desirable in some cases in this socialized world, the danger of uneconomic subdivision of holdings must be avoided, for our object must not be to stabilize the living standards at a level that leaves no room for progress. Any improvement in production in the highlands following investigation and the intensification of cultivation must aim at improving the standards of living of the present occupiers rather than as grounds for encouraging a further increase in population density. Outlets must be provided elsewhere for the landless and must be more attractive for such people than hanging on as parasites and holding back social progress in the *kihamba* lands.

It must be emphasized here that the greatly increased planting on the lower slopes of annual crops, maize interplanted either with beans or finger millet, is largely due to the inability of the *kihamba* lands to feed the people any longer, as witness the periodically severe banana shortages in recent years and the contraction there of unoccupied land or *kihamba* annually cropped land on which finger millet, beans, sweet potatoes and yams were formerly planted. Although nowadays superfluous or abandoned lands may not become available for redistribution, the recently recorded occurrence of banana borer on Kilimanjaro will probably make it necessary for the chiefs to regain stricter control over neglected banana plantations under the powers they have taken for the control of banana borer.

The mountain lands may be divided into the *kihamba* plantation, the *kihamba* annual cropping and grazing lands (the latter becoming increasingly reduced by the planting of bananas and coffee), and the bracken lands above 5,000 ft. In the opinions of Griffiths [8], Johnston [10] and of Missionary Gutmann [9], and ruling out the not inconsiderable number of the estates of ten to thirty acres, it may be said that the area of *kihamba* enclosed in the traditional *Dracaena* fence amounts to some 1½ acres (half under bananas and half under coffee) with one acre of unfenced land growing finger millet, beans, sweet potatoes, taro and yams, and a few minor crops such as wheat, potatoes and peas, and finally the fallow lands and grazing greens. In addition, Griffiths [8] estimated that in 1930 there was available in the lowlands one acre of grass per head of cattle, quite inadequate for their keep had not stall feeding been adopted. Since then the lower limit of banana plantations has moved down the mountain-side two or three miles in many places and the area under maize, beans and finger

millet has increased out of all recognition so that the areas of grassland available for cutting for fodder and thatch has contracted appreciably and is now almost non-existent (except on alienated land in some chiefdoms such as Kibosho, Uru or Marangu) or is confined to the poor eroded lands in others—Kilema, Kirua and Old Moshi. On the other hand, large quantities of weeds and maize, bean and finger millet stover are carried up and fed to the cattle and small stock. No Chagga woman returns from her day's work in the plains empty-handed. While the Chagga attribute the decrease in the number of their live stock to disease, the fall in cattle from 132,000 in 1930 to 105,000, and of sheep and goats from 202,000 in 1930 to 153,000 may in part be due to decreased fodder supplies in both highlands and lowlands and to the greater preoccupation of the Chagga with their coffee and with their lowland annual crops, maize now taking equal importance in their diet with bananas.

Chagga Psychology

While submitting the Chagga to a close study, his reaction to all benevolent investigations and planning for the future must not be neglected. We have seen that he is hard-working, progressive, willing to adopt improvements when he is convinced of their worth, and that he is responsive to a strong lead. On the other hand he does not appreciate too close a study or investigation into his private affairs and he is greatly influenced by his clan elders, more so in fact than by his chiefs, as witness the refusal to accept land registration. Similarly, attempts to conduct an agricultural survey have been opposed either from fear of exposing the clan holdings as well as those of large land holders, or from fear of the introduction of graduated taxation, the attempt to introduce such in the neighbouring Pare district was followed with close interest. Interference with their water system and water rights would also meet with similar opposition. Their reaction is, in fact, similar to that of the conservative landowner or business man to socialization. The Chagga do not admit, as Moffett [12] has recently shown, Government's title to their land. That they will respond to a strong lead or a firm decision by Government is shown by their willingness to pay additional taxation for forests (50 cents), for the improvement and co-ordination of Native Authority and Mission education (Sh. 2) and for development of social services and the reorganization of their native administration (Sh. 3/50) or further by their acceptance of the levy placed on their coffee by the Moshi Native Coffee Board, thus raising a revenue about equal to that of the annual Sh. 19 hut tax.

To intensify production in the highlands, to control the irrigation system to better advantage and to develop the lowlands will require investigation and study, and the Chagga's response to strong leadership should react favourably to the Wilson Report [16] recommendations that strong administrative and technical teams "should make topographical, hydrographical, agricultural and pastoral surveys of those areas, in consultation with officers of the Tsetse Research and Medical Departments, with a view to the general reorganization of the economic life of the region. These teams should also be responsible for putting into execution the development schemes drawn up as a result of their researches".

Irrigation and Water Supplies

The southern face of Kilimanjaro is served by a vast network of irrigation channels carrying to nearly every *kihamba* the water from the abundant rivers, streams and springs that originate mainly in the forest belt below the snow cap of Kibo. The origin of the furrow system is lost in the mists of antiquity; some think that the art could only have been brought by an alien tribe accustomed to the practice of irrigation in their own land, others that it was found in existence on Kilimanjaro by the incoming alien tribes. However the system may have been evolved it is remarkable how the large furrows have been led at very gentle gradients out of the rocky gorges 500 or 600 feet deep, of such rivers as the Kikafu and Weruweru. The water supplies are not inexhaustible especially as the major spring gushers rising in the lowlands command but little of the semi-arid lowlands before joining the Pangani (Ruvu) or the Kikuletwa Rivers to leave the district, and there is also the restriction imposed on the utilization of water by the Pangani Falls hydro-electric scheme's guaranteed minimum flow.

Strong criticism, of course, has been levelled at the wasteful Chagga system of allocation and utilization of the waters in the furrows. Teale and Gillman have recommended a complete survey of the furrow system with a view to controlling a more economic distribution of water, thereby releasing a proportion of the

water for use elsewhere. This is one of the difficult political tasks that awaits implementation, and it must be emphasized that the system of the maintenance of the furrows and the allocation of water supplies has been run since its foundation completely independent of Government and the native authorities and that, unlike land disputes, there is no litigation on water matters in the courts. Interference with such a system cannot be undertaken irresponsibly for, like nationalization, central control would involve high costs of maintenance, loss of contact with users and refusal of users to undertake their obligations without payment. Let us see what it would involve.

The Water Unions, as described in reports by Griffiths [8] and Missionary Gutmann [9] are highly complex associations built up during the early history of the Chagga tribe. The large furrows leading from the natural streams have been created either by the chiefs, who retain control of them, or by the clans for the use of the clan estates. In addition, there are minor irrigation schemes created by individuals or small associations of individuals who, "chiefly owing to the engineering difficulties or isolation, have not been able to participate in one of the main schemes. Most of the furrows are known by the name of their first constructor and are to-day under the control of his descendants who preside over Water Unions". The Union comprises the president or headman, the clan users and such new members as may have been admitted to the association provided they pay the participation fee of a small quantity of beer and perform the duties, upon pain of loss of rights, of carrying out the work allotted to them on the care and maintenance of the furrows.

The president, under his powers, may "call out all members of the irrigation union for the purpose of repairing furrows or cleaning them after the rains, during which they are often permitted to fall into disuse. He presides over the meeting which arranges (*a*) the distribution of irrigation in the coming year, such irrigation proceeding in accordance with rotation when once decided upon; (*b*) the exclusion of offenders against the water rules from further participation; (*c*) the inclusion of new members with the consent of the Water Union. Amongst the offenders would be those who failed to appear or send a substitute when called upon to effect repairs, without due excuse made to the headman".

In return for these duties the president has certain privileges, including "the right to receive water on every market day (generally once a week, but in some areas twice). The headman is thus in a position to modify any hardship in the rules by a gift of irrigation water in any case of ascertained drought and has the right to receive gifts (generally finger millet for making native beer) from the recipient of water on these particular days. The underlying idea is to avoid the injustice which rigid water rules might impose upon individual members in an uncertain climate.

"The privileges of members consist of an equal share of water, of voicing their opinions for a decision by the headman in all matters pertaining to the furrows, of admitting new members and dismissing offenders. The duty, upon pain of loss of rights is to carry out the work which has been alloted to them." (The foregoing are abbreviated abstracts from Griffiths [8].)

It is no doubt surprising that such a vast quantity of water should be required for irrigation in the southern Kilimanjaro highlands with their plentiful rainfall. While criticism is levelled at both the necessity for and the wasteful methods of irrigation by the Chagga on the well-watered southern slopes, Gutmann [9] counters these assertions by pointing out that Chagga irrigation, rightly or wrongly, is firmly established and has been a fundamental factor, in conjunction with stall-feeding of cattle and manuring, in developing their high standard of cultivation and is necessary for its further improvement. Any endangering of their irrigation system would force them back to a more extensive form of husbandry with attendant economic and social decay. He points out that the short rains in the well-watered southern banana belt start too late and are too unreliable to justify cropping without irrigation. It has previously been noted that the short rains are of vital importance in maintaining a constant supply of bananas throughout the year—their failure which may be partially mitigated by irrigation, presaging a serious food shortage six to eight months later. Teale and Gillman [15] have shown that the irregularity and unreliability of the rainfall of the semi-arid lowlands penetrates into the more humid highlands. Gutmann counters the argument of wasteful utilization of water by pointing to the existence of numerous Chagga dams (for conserving the night flow of water) which had in some places reached their limits as in Old Moshi with 79 dams or Mbokom with 45. Teale and Gillman call for experimental investigation into the utilization of water for crops

and guidance to the Chagga from the Agricultural Department for its economic application in order to release a proportion of the water for use to better advantage further afield in the foot plains. With the European staff in the district at a lower level than before the war, this has not yet been done. However, £3,000 has recently been granted from the Development and Welfare Fund for the improved conservation of water in those existing furrows whose tail waters debouch on the lowlands, by the construction of intakes, sealing of leaks, improvement to dams and so on.

On eastern Kilimanjaro a very different aspect is presented. Here the rivers are seasonal and, except for a trickle in the Lumi, soon recede to the forest edge. Irrigation, therefore, is very restricted and water has to be drawn from considerable distances for domestic consumption. Another very serious result has been the lower standard of preparation of Rombo coffee for which abundant fresh water is essential. Cattle, too, have to walk long distances to water, often across the Kenya border, and thereby causes serious erosion. The Moshi Native Coffee Board, in a £12,000 scheme, has piped water from the forest edge at six points to make water more readily available for coffee preparation. It is highly desirable that this popular scheme should be extended, in conjunction with Government and the native authorities, at some future date, to supply the lower *kihamba* lands and provide watering points in the grazing areas to reduce trampling. The fact that under these circumstances the cultivation of bananas is at all possible in Rombo can only be accounted for by the greater and more certain incidence of the short rains in that area. Nevertheless, Rombo suffers from crop failures and food shortages to a degree much greater than the southern divisions on which it draws in time of scarcity. In fact, the interdependence of the three divisions, due to their dissimilar conditions, is great. The people of Rombo rely on Hai and Vunjo for food in periods of scarcity and for employment in time of economic stress while the people of Hai and Vunjo are dependent on surplus finger millet from Rombo for beer-making and for labour to help pick the coffee crop and to cultivate the lowland maize gardens.

Soil Erosion

Soil conservation practices differ in the highland gardens, the southern lowland annual cultivation lands and the eastern annual cultivation and grazing lands. In the highlands we have the contiguous orchards of bananas and coffee bounded by compact hedges and protected by shade trees and shelter belts, all tending to break the force of the rain, to slow down run-off, to reduce desiccation and to give a certain measure of protection to the soil through leaf fall. Further protection is afforded by manure and interplanted crops. The retention of the soil within the *vihamba* by the dense hedges is very apparent and on sloping land the banks separating one *kihamba* from its neighbours above and below are appreciable. The heavy and prolonged main rains generally preclude weeding until July, an added protection. At the onset of the rains the rivers run red due mainly to wash from the numerous roads, paths and tracks, but the waters clear as the rains continue. The greatest danger to the soil is from irrigation of the finger millet crop (planted after the main rains) and from irrigation of the bananas and coffee at dry periods of the year. With their greatly increased occupations, many Chagga do not give that careful attention to irrigation that was characteristic of the original system and many flood their gardens with a strong and destructive flow of water. Fortunately, in the last ten years the area under irrigated finger millet has contracted appreciably as vacant lands have been planted to bananas and coffee so that it is now only undertaken on a large scale at the western end of the district.

It has been shown that by the failure of the banana crop to supply the full needs of the growing population, and by the stimulus of the war effort, there has been a vast expansion of annual crops in the lowlands involving the clearing of many thousands of acres of bush, mostly combretaceous, and even, in areas of greater population density, the acquisition or leasing of undeveloped alienated lands. One of the first soil conservation measures introduced into Moshi District was associated with the introduction of the onion crop about 1928, grown on flat beds with graded irrigation channels. Maize production has been responsible for the greatest clearing and opening up of the lower southern slopes. Here it is interplanted with beans or rain-grown finger millet, the latter an expanding and less destructive innovation balancing the decrease in irrigated finger millet in the highlands. The bush is cut back but, despite extensive propaganda, it is seldom stumped to permit of tractor ploughing so that regenera-

tion is rapid. After the first year or two sheet erosion in the blocks of cultivation, with its attendant gullies, becomes apparent.

Kilimanjaro received earlier and more concentrated attention to soil conservation measures from the Agricultural Department and the native authorities than most other districts. Native authority rules which closed the deep rivers, the smaller streams and gullies and the steep slopes to cultivation, and prescribed soil conservation measures to be adopted in cultivated lands, were promulgated at an early date and were consolidated in 1940. Representatives of the Agricultural Department and the native authorities have demarcated the protected river banks and, as the expanding lowland cultivations reveal fresh gullies, or ravines caused by springs, these are similarly demarcated. Gangs of trained levellers lay out level contours across all annual cultivations (whether in lowland, highland or forest) according to the season and supervise the construction of contour banks with earth, trash and stones. After planting, these are further augmented with weeds. With the onset of the rains hedges are planted, both to support and strengthen these banks against accumulations of water and to form a permanent demarcation from year to year. The most suitable and popular hedge plant is *Coleus kilimandscharicus*, which is short, upright, compact and hardy. While the planting of Elephant Grass has been encouraged, it has not met with a ready response and in Rombo the planting of indigenous perennial grasses is pushed to supply fodder. Although contour banks are general throughout all annual cultivations, contour hedges have been adopted to a greater degree in Vunjo and Rombo than in Hai. It will be clear from these types of soil conservation measures that, where heavy downpours of rain occur before the crops are sufficiently established, an accumulation of water at weak points in the banks causes serious breaks and wash over a considerable area of slope. In considering the mechanical clearing and cultivation of the lowlands the local authorities have in mind the possibility of utilizing the machinery in the off-season to establish more substantial soil conservation measures in the larger blocks of cultivation.

The eastern or Rombo annual cultivations and grazing lands, below the banana belt, represent a more advanced stage of the conditions described in the previous paragraph. They are aggravated by more severe dry seasons, a desiccating wind, a more erodible soil and by cattle. Though the quantity of live stock may be below the requirements of the people for nutrition and manure, they are, without stall feeding, in excess of the carrying capacity of the land during dry periods of the year. In the annual cultivations the short rains are more pronounced on this side of the mountain so that two crops a year may be reaped. An almost pure stand of rain-grown finger millet or a smaller area of beans with the long rains is followed by an almost pure stand of cowpeas or, again, a smaller area of beans with the short rains. This grain-legume rotation is practised on large contiguous blocks of land amounting altogether to many thousands of acres. No appreciable bush reserve remains until the Kenya border is reached, the balance of the land being devoted to grazing. These large blocks of land have enabled the gangs of levellers to lay out long stretches of contour banks, at the same time ignoring the boundaries of individual plots. The support of the chiefs and elders has been forthcoming to the extent that they organize the communal construction of contour banks, irrespective of owner, right across blocks so demarcated. The hedge planting is left to the individual. Erosion in the Rombo grazing lands is mentioned elsewhere. A start has been made in laying down reclamation trials and demonstrations to determine the best methods of regeneration, re-grassing and subsequent pasture management, with suitable propaganda to gain the support of the chiefs and people for communal reclamation. The Development and Welfare Fund has earmarked £3,000 for this work.

Manure, Live Stock and Tsetse Fly

The prevailing system of stall-feeding the cattle in the southern divisions of Hai and Vunjo, in the past a practice attributable to the presence of tsetse fly in the potential lowland grazing areas has already been noted, as has the fact that without stall-feeding the total area of the grasslands would be insufficient to carry the cattle population. In Vunjo there has been an increase in the lowland grazing and tsetse fly appears to have receded in lower Kilema and Kirua Vunjo due to increased settlement and clearing and to removal of trees for firewood and building. The number of cattle, sheep and goats on Kilimanjaro, based on figures kindly supplied by the Veterinary Department in Moshi, are given in Table III.

TABLE III

Livestock on Kilaminjaro—1946

Division	Number of Tax-payers	Cattle	Sheep	Goats
Rombo..	12,500	24,000	16,000	50,000
Vunjo ..	11,000	28,000	11,000	23,000
Hai ..	19,500	43,000	24,000	29,000
Total..	43,000	95,000	51,000	102,000

The figure represents about 2¼ head of cattle and 3½ of small stock per Chagga family (or 0.6 per head of the population as against 1 estimated by Griffiths [8] in 1930). The high number of goats in Rombo should be particularly noted. There is in addition a constant stream of slaughter stock coming on to the mountain from the pastoral districts of Dodoma, Singida, Mbulu and Masailand through the Weruweru cattle market, their number fluctuating with the prosperity of the Chagga from their coffee. This effect is noticeable even over short periods, as in early 1947 when the money from a coffee crop, reduced by drought, diverted food to the black market. There is little delay in slaughtering the cattle after they have been purchased by the butchers so that the amount of fertility which they produce is negligible, for the Chagga have not yet learnt the use of feeding stuffs for fattening store animals. The subsidiary trade in hides is enhanced in value by the system of shade drying undertaken by the Kilimanjaro Native Co-operative Union. Table IV summarizes the number of cattle passing through the Weruweru cattle market for slaughter while, in assessing the amount of meat eaten by the Chagga, account must also be taken of the annual slaughter of culls and male stock from their own animals.

TABLE IV

Cattle Purchases—Weruweru Market

Mean of Three-year Cycle	Number of Cattle Sold	Approx. Value	Growers' Receipts from Coffee
		£	£
1929–31	9,400	22,000	—
1936–38	16,900	32,000	37,000
1944–46	33,700	116,000	193,000

It is shown in this paper that preoccupation with lowland cultivations and the increasing distances to the fields to cultivate and to carry food, fodder and fuel is endangering the manure supplies for the homestead orchard crops as well as their adequate cultivation. In the eastern division of Rombo, and to an increasing degree in eastern Vunjo, cattle are grazed by day in the lowlands and returned to the *kihamba* stalls at night. In some places, particularly in Vunjo, they are penned in the plains. Thus not only are the manure supplies available to the *kihamba* depleted but the grazing lands become seriously eroded as the grass cover is denuded. Deep tracks are worn in transit by the cattle to the plains or in search of water.

Another danger to the highland areas of Rombo is the practice of stall-feeding goats, though browsing might be a greater menace. In Hai and Vunjo the trees in the *vihamba* are allowed to grow to provide excellent shelter for the bananas and coffee, from drying winds and the hot sun. In Rombo every available tree, and the most popular *Trema guineensis*, is pollarded and fed to the goats so that in the two dry periods between the long and short rains the hot desiccating winds from the plains scorch and fray the bananas and reduce their yields, thereby aggravating the periodical food shortages. An increasing realization of the danger is being brought home to the people, and particularly their leaders, as the areas available for grazing shrink with the spread of the banana *vehamba* down the mountain with the increasing cultivation of grazing lands by the expanding population.

The tsetse fly is not a problem in Rombo and parts of Vunjo but it is a limiting factor in the lower slopes of Hai and the chiefdoms in the plains, by restricting cattle grazing and mixed farming. It was apparent in the years preceding World War II that, besides restricting Chagga expansion and settlement in the lowlands, the occurrence of *Glossina swynnertoni* in the Moshi district (held back, by a narrow gap, from bush suited to its requirements across the Kenya border and extending in blocks southwards to the sleeping sickness foci at the southern end of the Northern Province) constituted a serious threat to Kenya, while *Glossina pallidipes* prevented the development of the lowland estates in the Moshi district on mixed farming lines to alleviate monoculture. The recent survey by A. G. Robertson, Tsetse Research Entomologist, has demonstrated the presence of five species of tsetse in the Moshi district, *G. brevipalpis*, *G.*

austini and *G. longipennis*, being found in the forest of the lowland forest reserves, and constituting a danger to neighbouring settlements.

Fuel Supplies and Building Materials

We have seen that the highlands of the southern divisions of Hai and Vunjo are well wooded and that in Rombo this effect is restricted by the pollarding of trees to feed goats. The Chagga has, therefore, in his boundary hedges and coffee shade, trees as reserves on which to draw for firewood, banana props, wood for making beehives, water containers, trays, spoons, rough furniture and timber, as well as poles, withies and tie-stuffs for building. But the supplies are far from adequate and loads of wood and poles are carried up to the lower villages, and down from the forest to the upper villages, leaving the middle areas the worst supplied because of the distance. With increased clearing of the combretaceous savannahs, supplies from the lowlands are decreasing. Supplies from the closed ravines are restricted and greater use could be made of them for the planting of trees and fodder grasses. For the Chagga living near the forest on the southern slopes the trunks of the tree ferns have been largely used in the past as a most durable ant-proof pole for building and thousands have been removed annually from the forest. In the past this forest was drawn on for unlimited supplies of building materials, fibres, tie-stuffs, firewood and bedding for live stock. This has had a serious effect on the composition and value of the lower forest, and forced the development of a new system of utilization which has recently been described by Baldwin [3].

The lower half mile of forest along the southern and eastern faces of the mountain, some 60 miles from its western to its northern extremities, was demarcated for development and utilization on behalf of the native authorities. The poor forest is gradually to be cut out, in accordance with a planned forest rotation, by squatters who will get the benefit of the timber as well as three or four crops. During the last crop trees will be planted. In practice, some 5,000 acres will be re-afforested in this way, another 5,000 acres comprising high forest are capable of improvement, while a further 10,000 acres are too steep for clearing. It is planned to supply firewood, withies and poles within close proximity to each chiefdom with, probably, centralized timber circles. The Chagga chiefs readily fell in with this plan and the people agreed in 1944 to contribute an additional 50 cent tax for this work, bringing in an annual revenue of £1,000, whilst revenue from the sale of wattle bark from the earlier plantings has been substantial. To date some 1,200 acres have been cleared and planted under the scheme and planting each year continues at a rate sufficient to meet Chagga requirements. Transport is a vital factor here because, in practice, only the people in the upper villages benefit. This has been shown by the slow rate at which poles have been removed from the early felled wattle plantations in the upper forest area. There is no corresponding scheme as yet for the lowlands where the combretaceous savannah is being rapidly depleted by cultivation.

Slopes in this half-mile strip are steep and the Agricultural Department, with its gangs of levellers, has actively co-operated in ensuring that substantial contour banks of trash, tree trunks and branches are put in. Thus the land made available for cultivation, limited though the area may be, has assisted many of the inhabitants of the upper villages to supplement their food requirements. A question, possibly premature, is what will happen to them when the whole half-mile strip has been planted to its first rotation of trees if natural regeneration is employed thereafter. If labour continues to be required in the forest, and if the Chagga taxpayer is still to contribute, squatters will continue to require some inducement to work and some security of tenure in the assurance of two or three years' harvest. It is of interest to note here the high agricultural production of some 300 Chagga and Kikuyu squatter families at Rongai, on the northern slopes of Kilimanjaro. They grew a considerable surplus of marrowfat peas, white haricot beans, potatoes (supplies of the latter going as far afield as Tanga and Dar es Salaam), as well as seed potatoes which have been dispatched as far as the Southern Highlands. A heavy maize crop, taking eight months from planting to harvest at an altitude of over 6,000 ft., helps to feed the people of Rombo in times of shortage.

It will be seen from this brief description that the needs of the Chagga in the upper villages for wood have been most satisfactorily met by a tax contribution from the whole tribe. If, however, the cultivators of the middle and lower villages are to avoid giving an unnecessary proportion of their time to the search for wood, such outstanding problems remain as the siting of plantations and

the transport of fuel, timber and building materials. With no spare land in the middle villages, the Chagga may have to devote a greater proportion of their *vihamba* to tree growing, and to intensifying production of bananas and coffee on the reduced area.

Economy of Labour and Transport

So long as the banana crop, without competition from coffee, and supplemented by beans, sweet potatoes, yams, finger millet and a little maize from the highland annual crop lands, provided an ample margin to feed the Chagga, time was of little consequence in his life. It will have become apparent, however, in the preceding sections that the highlands are no longer self-sufficient. The expansion of *vihamba* down the mountain has pushed the grasslands, the tree lands and the areas for annual cultivation to what is becoming an uneconomic distance from the inhabitants of the middle and upper villages. A man and his wife nowadays may have to walk from five to ten miles to clear, cultivate, sow, weed, harvest and hump home on their heads their annual crops of maize, beans or cowpeas and finger millet. They also have to collect heavy bundles of grass two or three times a week for the live stock, as well as cut and carry a large bundle of firewood. Then there are the bananas and coffee within the *kihamba* to be tended along with yams, sweet potatoes and beans interplanted or growing in adjacent plots. Moreover, soft weeds for bedding stock, tree and hedge loppings, banana stems and leaves have to be cut and chopped for the live stock. Their stalls have to be cleaned out and the manure placed round the banana clumps while the finger millet, bananas and the coffee have to be irrigated when necessary. Time has to be found to meet the calls of the Water Union, to attend district meetings or the market, to buy the daily meat or other goods from the native shops, or to attend or assist with the communal ceremonies of births, marriages and deaths, house-building and so on. Periodically a new house has to be built for a new wife or when the old home collapses or re-thatching may become necessary. Neighbours assist with this and beer is provided for smooth working, but large quantities of thatching grass, poles, withies and tie-stuffs have to be collected. As coffee planting has expanded in Rombo, labour from that source has declined.

One of the biggest problems which faces any farmer is the necessity of spreading his operations as evenly as possible over the seasons in order to avoid peaks, with which he and his labour cannot cope. On Kilimanjaro the heaviest work on the coffee crop falls between November and March when full attention is required for the picking and preparation of the coffee, pruning the trees and spraying against *antestia*. Competing with this work are those of clearing land and cultivating the fields in the lowlands for the annual crops. It is important that this work should be completed early for, should by good fortune rain fall in February, it is worth three bags of maize per acre in yield over a crop planted in March, while a March planting will generally beat an April planting by another three bags per acre.

World War II divided the past from the future in that it created a higher price for coffee and caused the vast expansion of lowland cultivation. The time is approaching when the economy of the Chagga must be divided into three separate but complementary functions. The principal income of the district will continue, for some time at least, to be earned by the highland coffee growers, who will only be able to provide but a proportion of their food themselves from their bananas. Their income must suffice to purchase the balance of their food requirements and to pay the heavy costs of transport of food, fodder, fuel and building materials. Even now appreciable quantities of the lowland harvest and of thatching grass are transported by lorry up the mountain but not all the Chagga can afford to pay the hiring costs.

The contribution of the surplus population must be to develop the lowlands as the granary of the district either by settlement or by collective or mechanical block cultivation. Besides their own requirements it will be necessary for them to provide the surplus food required to feed the highland population as well as their cattle with fodder and concentrates, so that besides maize, beans, finger millet and root crops it will be necessary to grow grasses and lucerne for fodder and hay, cotton for seed, groundnuts for cake and so on. The income of the surplus population will therefore come from two sources, the highland Chagga and the sale of cash crops. It has already been pointed out that a vast irrigation network, comparable in volume to that existing in the highlands will have to be developed to safeguard this granary from failure since it is situated in a semi-arid area.

Connecting these two communities there must be an efficient and cheap transport service, for the greatest drawback to progress is the head load. Large numbers of Chagga own lorries and run unorganized bus and transport services to all corners of the district, except during the rains when all heavy transport is immobilized for two or three months. All the lorry owners are members of the Chagga Transporters Association on which, if it were to receive the attention that the Kilimanjaro Native Co-operative Union has received, could be founded the necessary transport system to carry out the scheme, putting order into the present chaos. The principal feeder roads will require improvement to an all-weather standard to connect with the main Taveta–Moshi–Arusha road which is to be made into an all-weather road under the development and welfare plan.

Lowland Expansion Areas

The sparsely populated lowlands have featured from time to time in some of the preceding sections and it may be wondered why a progressive tribe like the Chagga has hestitated for so long in occupying and developing them. The arid contrast of these lowlands to that of the highlands, their uncertain crop yields and the large proportion of tsetse infested bush require a concerted plan directed and assisted by Government. The Wilson Report [16] has recommended the allocation of certain alienated lands, many of them marginal and therefore undeveloped but readily accessible, to absorb the surplus population pending the decision by Government as to the best means for opening up the principal area of the lowlands which it proposes for absorbing surplus Chagga. The outstanding problems are bush clearing, the eradication of tsetse fly and the provision of adequate water supplies or, failing sufficient for irrigation, of drought-resistant crops, for it is considered that the rainfall in these areas suffices in only two years out of five to bring through safely any but a moderate crop. This is, of course, one of the outstanding problems of Tanganyika, namely, the lack of seed supplies of quick maturing, drought-resistant crops available at short notice for late planting should early rains or early planted crops fail. The only remedies for an early cessation of the rains other than the early planting of short-term crops are adequate conservation of the rainfall by soil conservation measures, irrigation to carry the crop through to harvest and manuring.

In 1944 King [11] proposed alternative methods of developing the lowlands, viz. by individual settlement and cultivation, by block settlement and cultivation with machinery owned communally or by collective mechanical cultivation of large blocks by and on behalf of the tribe. There is no doubt that each method can be adapted to the different conditions found in the lowlands, but the clearing of land whether by hand or mechanically for machine cultivation must be closely supervised, for on his own land the Chagga, even though he may ask for the hire of a tractor and plough, is very tardy about removing stumps.

Major problems, too, in the lowland development schemes will be the provision of adequate soil conservation measures in these highly erodable lands and the maintenance of fertility, particularly by the provision of organic manure, should a high degree of mechanization be employed. In this respect the groundnut scheme will be watched with interest.

The Alienated Lands

The Wilson Report [16] describes how the occupation of Moshi District by the Germans in the last decade of the nineteenth century was followed by a "stream of German settlers who took up land mostly in the areas below the then very restricted tribal lands but above the line of the present Arusha–Moshi–Taveta road. These alienations, which continued up to the outbreak of the 1914–18 war, resulted in the virtual enclosure of the ring of tribal land. The land was largely unoccupied and unused by the native peoples, the upper land carved out of the forest being not only ample for their comparatively small numbers, as they were kept in check by disease, tribal and clan warfare and other causes which have since ceased to operate, but was also more desirable to them for reasons of health and security from their enemies than the lower lands". Teale and Gillman [15] record that some Germans appreciated that alienation was proceeding without regard to the future needs of the tribe. The Wilson Report records that in the Moshi District there are some 250 alienated holdings totalling approximately 183,000 acres. Of this it recommends the acquisition of 17,381 acres for the Chagga, mostly undeveloped land, to meet

their immediate needs pending the development of the lowlands.

The alienated estates in the past have been and to a certain extent still are of benefit to the Chagga. It was on the estates that the Chagga first learned the value of money and of coffee, to the planting of which they were able to apply themselves with industry when the stimulus was given by Major (now Sir Charles) Dundas. They still rely on employment on estates to make up any deficit in their income brought about by fluctuations from year to year in the yields of coffee, bananas and maize. Though small areas of land reverted to the Chagga after World War I, it was not until the 1930's that the Chagga began to cast covetous eyes on the lands of their non-native neighbours to relieve population pressure in preference to a permanent descent to the plains. World War II gave them hope of acquiring a proportion of the German farms in the district, totalling nearly 41,000 acres. In fact the Chagga have, through Government purchased farms by agreement with the owners. This has been done during the last ten years or so in the worst congested chiefdoms to the extent of about 4,000 acres. The Chagga pay a voluntary levy from the receipts for their coffee until the purchase price has been paid off.

This latter method of expansion may continue in the future and may well prove a satisfactory solution to both parties for many of the estates are too marginal for coffee owing to their low altitude or they were uneconomic for maize at pre-war prices, whilst others are at present being severely mined under irrigated pawpaws. The Chagga do not lack the means for purchasing land, for the total pay-out to Chagga coffee growers for the 1947–48 crop will fall little short of £300,000 after deducting all expenses and levies. European coffee production has declined appreciably in recent years in contrast to the expanding native industry, the latter being grown on the better lands where yields are more stable.

In 1947–48 the Kilimanjaro native coffee crop amounted to 4,250 tons, exceeding the 4,000-ton mark for the second time in its history.

It will be seen that, for the present at any rate, the presence of European estates in the Moshi District is a stabilizing factor in the Chagga economy and is, to a certain extent, educative, though in irrigation methods and soil conservation measures the Chagga hold the lead over many non-natives.

TABLE V

Coffee Production—Moshi District
(in tons of parchment coffee)

Mean of Three-year Cycle	European	African	Total
1929–32	1,188	904	2,092
1936–39	1,891	1,438	3,329
1944–47	976	3,117	4,093

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TRYPANOSOMA VIVAX IN THE CAMEL

Natural and Experimental Infection

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Natural infection in the camel with *T. vivax* has never been proved in Somalia, nor, it appears, elsewhere. Three experimental attempts are recorded:—

Pricolo and Ferrara (1920) in Eritrea infected a camel with blood infected with *T. vivax*. One transitory appearance occurred in the circulation after 16 days, there was no reappearance and the camel died from other causes.

Di Domizio (1925) in Somalia infected a camel with the bovine strain of *T. vivax*. It appeared in circulation after 16 days, later becoming scarce or absent, accompanied by severe clinical signs. This camel died after 37 days, but Di Domizio does not exclude other causes.

Bennet (1931) in the Sudan found trypanosomes in circulation 17 days following introduction and remaining until the 25th day, but *not* after. However feebleness continued until a clinical cure with Naganol was obtained.

With the object of throwing fresh light on the problem the following observations on natural infection plus results of experimental transmission done at Merca are offered.

Natural Infection

Camel No. III.—Female, brought for Surra treatment, 29th April, 1942. Suffering from acute trypanosomiasis with fever, lacrimation, unthriftiness and suppressed lactation, with a history of having been ill eight days. Fresh blood, positive; mobility of trypanosomes apeared excessive for *T. evansi*. Stained specimens diagnosed as *T. vivax* were proved later biologically. 100 c.c. of 1 per cent solution Tartar Emetic were introduced intravenously. Observation showed the disappearance of the trypanosomes from the blood, and 10 c.c. were inoculated into a sheep and a calf (both susceptible to *T. vivax*) with negative results. Following restoration of the camel to the native owner, he reported a satisfactory recovery.

Camel No. V.—Baggage camel; property of the Institute; admitted to infirmary on 17th June, 1942. Temperature 39.6° C.; depression; mucopurulent conjunctival discharge; condition fair. During the following days the temperature rose to 40° C. and was never less than 38.5° C. in the morning; there was profound depression and suppression of appetite. On the fifth day the temperature began to fall and condition improved; at the end of the tenth day the temperature was normal and the camel was sent out to graze. Microscopical examination showed blood positive for *T. vivax* which later disappeared from the blood stream; reappearing 28 days later on three successive days, after which they were not seen again during the seven months the camel was kept under observation.

Camel No. VII.—Baggage camel as above was admitted on 17th June, 1942, with a history of having been ill two days.

The same as in the case of No. V but of a milder nature. Temperature was on the first day 39.3° C., but fell on the second day to 38° C., and remained at this level for several days. (The normal temperature of working camels at Merca is 36.2° C. in the morning and 37.5° C. in the evening.) Blood was positive for *T. vivax* on the first day and for 15 days after. Then parasites disappeared, returning after 43 days for three days without serious clinical manifestations. Since then and for seven months afterwards the camel remained in good condition.

Camel No. VIII.—Baggage camel as above; admitted on 13th June, 1942. The camel seemed ailing, had lost appetite and was disinclined to move. On the 18th day the symptoms became aggravated and there was lacrimatory discharge, swelling of the prepuce and rise in temperature. On the 13th and 14th days blood examinations were negative for protozoa; on the 18th day, however, the blood was positive for *T. vivax*. This acute stage of infection declined after a few days and the animal was put back to work. Fifty-six days later trypanosomes reappeared for three days and the temperature rose slightly. This camel was again put under observation for five months without any trypanosomes being seen, and its condition remained good.

Transmission

The first case of natural infection observed was a camel owned by a Somali whose grazings were far distant from the Webi Shebeli; the other three cases were baggage camels belonging to the Institute which became naturally infected from a camel experimentally infected from the original case, which had been sent to graze with the Institute herd.

With regard to the mode of infection, in the case of the native-owned beast no certain views can be put forward, but the possibility of contact with tsetse flies cannot be excluded, even though the animal's home was far removed from any fly-infested area. With regard to the Institute's camels, observations are more certain. The Institute's grazings are free from tsetses, but are, of course, heavily infested with tabanids and stomoxys, and in view of the fact that the camel became sick 15 days after the experimental beast had been introduced into the herd the theory of mechanical infection due to *Tabanidæ* and *Stomoxys* is tenable.

EXPERIMENTAL INFECTION

Camel No. 1.—This animal was inoculated on the 8th May, 1942, with the blood of a sheep experimentally infected from Camel No. III (natural infection). On the eighth day *T. vivax* appeared in the blood, and rapidly increased in number during the next 24 hours, the temperature rising to 39.5° C. For the next three days the temperature remained high (maximum 39.9° C.), then it fell and thereafter only a transient rise could be recorded. On the contrary, however, for the next 14 days *T. vivax* were seen in numbers in the blood stream, after which they gradually disappeared. The clinical picture was typical of trypanosomiasis and for 15 days the animal was unable to be sent to graze. Regular examinations of blood smears were made up to the 2nd September, 1942, and all proved negative, although on the 40th and 45th days after infection *T. vivax* were demonstrated in gland smears.

Camel No. 3.—This animal was infected with the blood of a calf also experimentally infected from Camel No. III. After ten days *T. vivax* appeared in the blood stream and rapidly increased in numbers. The temperature rose to 40.5° C. with very severe clinical manifestations, and death ensued on the 23rd May, 1942. Post-mortem examination showed much emaciation and slight splenic hypertrophy.

Camel No. 4.—This animal was infected on the 6th July, 1942, with the blood of Camel No. VII (direct infection). On the tenth day *T. vivax* appeared in the blood, but during the next 24 daily examinations only on ten occasions were they seen again and then in small numbers. With the exception of a transient evening rise in temperature no definite clinical symptoms were observed, and the animal remained at work without any ill-effects.

Camel No. 6.—This animal was infected from Camel No. V (direct infection). After seven days *T. vivax* appeared in the blood in large numbers until the 21st day, after which they disappeared, but returned on the 27th day, after which they were not seen again during the period of observation, that is up to the 30th November, 1942. At the time the parasites were observed in the blood a rise in temperature was noticed. During the first 20 days the temperature was above normal and the animal fed badly, grew thin and showed abundant lacrimation. From the 12th to 17th day of illness œdema of the limbs was noticeable. After 30 days its condition became normal and the animal recovered.

MICROSCOPICAL EXAMINATION OF THE TRYPANOSOME

Motility.—The trypanosomes for the most part move rapidly across the field in a straight line.

Size.—Table I shows the length of 700 trypanosomes measured by Bruce's Camera Lucida method at an enlargement of 2,500 diameters. Table No. II shows the the width of 400 trypanosomes measured in the same way.

General.—The trypanosome is morphologically quite distinct from any other trypanosome of the camel. It appears to be a monomorphic type with little linear variation, more than 76 per cent ranging between 21 and 25 microns. The posterior half of the protoplasmic body seems to be the more developed. In its whole aspect the spindle has a scarcely pliable appearance owing to the few winding lines that it shows, most of the body curves being mild.

The nucleus of the flagellate occupies the whole width of the body. Its usual shape is oval and its position median. The kinetoplast is generally round and of remarkable size and its position is terminal or sub-terminal.

TABLE I

Distribution on the basis of length of 700 trypanosomes

Microns	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Average Length 23·22 microns
Number of Trypanosomes	1	4	2	16	41	72	118	153	108	82	53	36	11	2	1	
Percentages	0·74	0·57	0·28	0·28	5·85	10·58	16·85	21·85	16·48	11·73	7·51	5·14	1·57	0·88	0·14	

TABLE II

Distribution on the basis of width of 400 trypanosomes

Microns	1	1·2	1·4	1·6	1·8	2	2·2	2·4	2·6	2·8	3	3·2	3·4	3·6	3·8	4	Average Width 2·09 microns
Number of Tryp.	4	13	37	59	54	71	35	49	13	25	9	10	6	7	1	7	
Percentages	—	3·35	9·25	14·75	13·50	17·75	8·75	12·25	3·75	6·25	2·25	2·50	1·50	1·25	0·25	1·75	

The flagellum is quite evident, and the free portion varies from four to nine microns in length. In many of the trypanosomes (11 per cent) this free portion turns back and twists round the body.

The undulating membrane is inconspicuous and in many trypanosomes can hardly be seen at all; in others it appears very narrow and with few undulations; in others the undulations are recognizable.

Biological Tests

Laboratory Animals.—Seven guinea pigs, three rabbits, two cats, two dogs and three rats gave negative results.

Mule.—One animal was used. The trypanosomes found in the blood were scarce and were observed only from the 15th to the 17th days after inoculation. There were no clinical symptoms.

Sheep and Goats.—Four sheep and three goats were infected, and all showed trypanosomes in the blood and died between 20 and 39 days after inoculation.

Cattle.—Four cattle were infected and all showed trypanosomes in the circulation. Three of the animals died.

Serological Test

In all naturally or experimentally infected camels the sera gave a positive reaction to the Bennet and Kenny test. All tests, except for Camel No. III, were made with serum taken from the animal before, during and after infection. Before infection the serum always gave a negative result: the flocculation appeared during the course of the disease and disappeared when the animal had recovered.

Conclusions

The morphological and biological tests carried out show that the studied trypanosome is *T. vivax*. No differences have been observed between this trypanosome and that observed by Di Domizio in Somalia in cattle.

These observations definitely solve the problem, until now unsolved, of the receptivity of the camel in respect to natural infection by *T. vivax*.

As to the nature of the infection, our observations lead us to believe that the disease, at least in the case of natural infection, has a rather mild course, but the small number of cases observed do not allow us to affirm this principle in a definite way.

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AN OBSERVATION ON THE RELATIVE VALUES OF SEVERAL GENERAL INSECTICIDES

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(*Received for publication on 28th October, 1948*)

During a recent trial of insecticides against *Lygus vosseleri* Popp. on young cotton at Serere Agricultural Station in Uganda the opportunity was taken of seeing the effect of the insecticides on the general insect populations of the plots. Being designed for the other purpose, the trial was not ideal for these latter observations and the figures obtained have to be qualified by certain factors, not all of which can be measured. Nevertheless, the differences between the results of the treatments are so striking that conclusions of interest can be drawn, even after making allowances for all these factors.

The Trial

The trial was divided into two replications, "A" and "B", in different parts of the farm. Each replication consisted of a strip of quarter-acre plots. Each strip had alternate control and treated plots, each treatment appearing once in the strip. As far as possible a full quarter-acre plot was used once on each strip for each treatment, but this could not be done in every instance owing to shortage of materials. The reductions are shown below:—

Pyrethrum Dust.—Half plot (⅛ acre) in "A" strip, full treatment in "B".

B.H.C. Spray.—Full treatment.

B.H.C. Dust.—Full treatment.

D.D.T. Spray No. 1.—Last dose omitted from "A" and reduced in "B".

D.D.T. Spray No. 2.—Half plot in "A", omitted from "B".

D.D.T. Dust.—Full treatment.

The cotton in "A" had been sown five weeks and that in "B" six weeks before the trial started. The details of the insecticides are as follows:—

Pyrethrum Dust.—One part by weight of pyrethrum to two of diatomite at 24 lb. per acre (i.e. 8 lb. pyrethrum per acre).

B.H.C. Spray. — "Agrocide Wettable Powder" at 4 lb. per acre in water (i.e. 0.24 lb. gamma isomer per acre).

B.H.C. Dust.—"Agrocide 1" at 40 lb. per acre (i.e. 0.1 lb. gamma isomer per acre).

D.D.T. Spray No. 1.—50 per cent dispersible powder at 3 lb. per acre (i.e. 1.5 lb. D.D.T. per acre) for the first four doses, but last dose omitted on "A" and reduced to 2 lb. per acre (=1 lb. D.D.T. per acre) on "B".

D.D.T. Spray No. 2.—"Guesarol E., Spray Powder R.493", a 5 per cent powder, at 30 lb. per acre in water (i.e. 1.5 lb. D.D.T. per acre).

D.D.T. Dust.—One part by weight of "Ditrene" 42 per cent wettable powder to nine parts of Kaolin at 30 lb. of the resultant 5 per cent mixture per acre (i.e. 1.26 lb. D.D.T. per acre).

The dusts were applied with a rotary hand-blower, with the nozzle pointing sideways. Each plant was dusted directly and also usually received drifted dust. The sprays were applied with a knapsack sprayer, working at pressures of 40–110 lb. per square inch, with the nozzle directed downwards in order to drive them into the buds frequented by *Lygus*.

The dosages of insecticides described above were applied five times at weekly intervals.

The author's casual observations on the "B" plots at the time of the first application led to the making of the main observations. These consisted of a regular search by an African assistant for dead and dying insects and other arthropods in the treated plots. In each plot the search started about half an hour after the end of treatment and lasted about an hour. The arthropods found were put into bottles. Any which recovered were released and not counted. Such recovery was especially common in the pyrethrum plots. Most of the searching was done by a somewhat inexperienced assistant, a fact which probably accounts for the absence in the collections of very small insects such as *Aphis*, *Bemisia* and *Empoasca*.

At the end of the trial the arthropods from each plot were classified by groups. The results are summarized in the table.

PRELIMINARY OBSERVATIONS

The casual observations by the author in the "B" plots are described here, because they include some insects not collected by the African assistant.

The Pyrethrum Dust plot contained a considerable number of dead and dying small insects. Diptera outnumbered all the rest and included Calyptrates and Acalyptrates, a few Dolichopodids, one Cecidomyid, but no Syrphids. In addition, there were one spider, a number of Hemiptera (one *Helopeltis*, one *Coreid*, one *Aphid*, several *Bemisia* and several *Empoasca*), several beetles (seven Coccinellids, one Anthicid and one Curculionid), one Tenthredinid, and four Lepidoptera (one Noctuid and one Lymantriid larva, and one Tineoid and one Lycaenid adult).

The B.H.C. Spray provided two Acridids, one Chrysomelid, one Syrphid, a few Formicids and a Lepidopterous caterpillar.

The D.D.T. Spray No. 1 gave one Coccinellid and one Chrysomelid.

The D.D.T. Dust plot revealed no dead or dying insects, but only an *Empoasca* nymph and a small Mirid, each of which looked a little uncomfortable with a coating of D.D.T. dust all over them.

ANALYSIS OF COLLECTIONS (*See* TABLE I)

General Effectiveness of Slaughter by the Six Treatments (*Table I, line A*)

The numbers of corpses per treatment showed striking differences:—

	Corpses
1. B.H.C. Spray	376
2. Pyrethrum Dust	220
3. B.H.C. Dust	141
4. D.D.T. Spray No. 1	112
5. D.D.T. Spray No. 2	88
6. D.D.T. Dust	26

Although these surprisingly big differences are subject to some qualifications, as is shown below, they are too large to be due to experimental error.

In interpreting the results shown in the table, allowance must be made for the fact that one end of the "A" strip, including the plots treated with D.D.T. dust and D.D.T. Spray No. 2, was in poorer condition than the rest and therefore probably had fewer arthropods on it. The reduction of the last dose of the D.D.T. Spray No. 1 on the "B" plot, and the omission of the last dose and the subsequent collection on the "A" strip, must also be allowed for. These two facts explain a small part of the low figures for all these D.D.T. treatments, but cannot possibly account for all.

Another point to be remembered is that death is quick with pyrethrum, less so with B.H.C. and slowest with D.D.T., so that the numbers of corpses picked up was disproportionately high with pyrethrum and low with D.D.T.

It is thought that the figures are not affected much by the use of only half plots for pyrethrum dust and D.D.T. spray 2 in "A", as the times taken in searching were more or less equal for all plots. The lack of the D.D.T. spray 2 treatment in "B" has been compensated for approximately by doubling the figures for the "A" plot.

The two D.D.T. sprays involved equal dosages per acre and are therefore directly comparable. The D.D.T. dust was somewhat weaker in strength, but proved to be disproportionately weak in killing power.

The B.H.C. spray was 2.4 times as strong in gamma isomer as the B.H.C. dust. If the number of corpses from the latter is multiplied by 2.4 it gives 338, compared with 376 for the spray, suggesting that the latter is a more effective killing agent, strength for strength.

Analysis by Systematic Groups (*Table I, lines B–P*)

The *Araneida* (line B) seemed to differ from the usual reaction in being not susceptible to pyrethrum, but numbers were small.

The *Diplopoda* (C) were unique in being killed only by sprays and not by dusts, and in that more were killed by D.D.T. than B.H.C.

For the *Orthoptera* (D) the order was similar to the general one, except that pyrethrum dust gave the lowest kill.

With the *Hemiptera* (E) the order was to all intents and purposes the general one, and none at all were found killed by D.D.T. dust. Of the important family, Miridæ (F), none

of the 40 corpses was found in any D.D.T. plot, the order of the other treatments being the general one. For *Lygus* alone the numbers were twenty in B.H.C. spray and four each in B.H.C. dust and pyrethrum.

The *Coleoptera* (G) comprised a third of all the arthropods picked up. The relative effectiveness of the treatments differed to some extent from the general one, pyrethrum was slightly superior to B.H.C., with D.D.T. spray 1 third but much less effective, B.H.C. dust was fourth, and D.D.T. spray 2 and D.D.T. dust were least effective as usual. Separate analyses of the four main families and of the remainder (H–L) show much variation. B.H.C. spray killed most in the Carabidæ, Scarabæidæ and the miscellaneous group. In the two last it was far ahead of the next treatment, and in the Chrysomelidæ it was only just second to pyrethrum. The superiority of pyrethrum against Coleoptera as a whole was due to its marked effectiveness against the Coccinellidæ, of which 88 per cent were found in pyrethrum plots, and the fact that it was most operative against the Chrysomelidæ. The mortality of Carabidæ and miscellaneous beetles under pyrethrum was only of the third order, and in the Scarabæidæ pyrethrum caused no deaths at all. The D.D.T. spray No. 1, third most effective against beetles as a whole, was a good second against the Carabidæ, a poor second against Scarabæidæ, and less potent against the other groups. B.H.C. dust varied from a bad second against the miscellaneous beetles to equal bottom against Carabidæ. The D.D.T. spray No. 2 and D.D.T. dust showed the usual low mortality against all groups.

Against *Hymenoptera* D.D.T. was much less potent than B.H.C. and pyrethrum. A feature of the experiment was a high mortality of Formicidæ (M), which provided a third of the deaths of all orders, while few other Hymenoptera (N) were found. Pyrethrum took third place against the Formicidæ, second against the rest.

With the Diptera (O) B.H.C. spray was first as usual, and pyrethrum was second but some way behind. D.D.T. spray No. 1 was third, B.H.C. dust fourth, and the usual pair at the bottom. Diptera were common resting on the upper sides of the cotton leaves.

The remaining insects, mainly Lepidoptera (P) showed some minor differences from the general order, but were few in number.

Analysis by Ecological Groups
(Table I, lines Q–U)

The arthropods were classified as far as possible into those living on the ground (Q) and those living or settling on plants (S–T). Both categories showed B.H.C. spray as easily the best killer, but, while pyrethrum was a good second against phytophilous insects, it was much less so against the ground arthropods. Against the latter the three sprays each killed more than any of the three dusts, B.H.C. as usual killing more than D.D.T. Against plant-living insects the order was substantially the general one against all arthropods. The latter order also applied to the remaining arthropods which could not be classified as either ground or plant-living (R).

An attempt to separate out plant-eating insects from the rest (S, T, U and V) showed little difference in relative mortalities. The inclusion of Diptera (O) and of the few adult Lepidoptera (part of P), which might have sucked the sprays while fresh, would also cause little change. It therefore seems probable that internal poisoning was unimportant compared with contact poisoning.

The large number of terrestrial arthropods picked up was surprising, as, apart from ants, they did not seem unusually common in the plots. The downward direction of the spray probably caused concentrations of insecticides around the bases of the plants, and perhaps numbers of ground insects came in contact with them at night.

Lygus spp., the pest against which the trial was directed, supplied 3 per cent of the total number of corpses picked up. The other corpses included a variety of useful, harmful and indifferent organisms. There was no evidence that any pest would increase through the destruction of its natural enemies.

Such an increase seemed likely at first in the case of *Aphis* in the sprayed plots. Small colonies of this pest were common, sheltered on the lower sides of the leaves from the sprays directed downwards. On the other hand, the two common species of Coccinellidæ and several kinds of Syrphidæ, the chief predators of *Aphis*, spent much time on the

upper surfaces, fully exposed to the spray. Certain species of Formicidæ tended the *Aphis*, and it has already been shown that large numbers of this group were killed. Actually, a general decrease of *Aphis* throughout the treated and untreated plots during the course of the trial was reported.

Practical Conclusions

The dosages of the insecticides used were such as might be expected to control *Lygus* and insects similar in stamina, according to work reported from other countries. The results show that as general insecticides at these dosages, B.H.C. killed far more than D.D.T., that with both substances sprays killed more than dusts, and that pyrethrum was intermediate between the strong B.H.C. spray and the weak B.H.C. dust.

The superiority of the B.H.C. spray was offset by the fact that it caused some scorching of the youngest leaves. If used at a level which would not cause scorching, it might perhaps be about as effective a killing agent as the pyrethrum dosage used.

Spraying eventually proved slightly quicker than dusting, and, as already noted, it killed more arthropods. On the other hand, the dusting gang of three men had to be increased to four for spraying, and a drum of water had to be provided beforehand for each day's work. Spraying is therefore more expensive than dusting, but the expense may often be justified, where water is not too difficult to get.

Pyrethrum dust proved surprisingly good as a general field insecticide and was actually the best against certain groups of Coleoptera. Unfortunately, these include the useful Coccinellidæ.

The trial was not conducted in such a way as to make full costings of much use. Nor are all the insecticides used available on the East African market. One useful comparison can be made, however, the cost at Kenya prices of the pyrethrum-diatomite dust works out at about Sh. 13, that of the B.H.C. dust, which was less effective, at about Sh. 23 per acre for one application.

Summary

1. Observations of dead and dying insects and other arthropods were made in a series of young cotton plots treated with insecticides for another purpose.

2. The insecticides were: (i) diluted pyrethrum dust applied at the rate of 8 lb. pyrethrum per acre; (ii) a B.H.C. aqueous spray giving 0.24 lb. gamma isomer per acre; (iii) a B.H.C. dust giving 0.1 lb. gamma isomer per acre; (iv) and (v) two aqueous sprays of D.D.T. giving 1.5 lb. D.D.T. per acre; and (vi) a D.D.T. dust giving 1.26 lb. D.D.T. per acre.

3. With both B.H.C. and D.D.T. a spray killed more of almost any group than a dust, but it was somewhat more expensive to apply.

4. At the strengths used, B.H.C. proved definitely superior to D.D.T. as a general field insecticide and also against every single group found except the Diplopoda.

5. The B.H.C. spray killed the most but burned the leaves and should be used more sparingly, when it would probably be about as efficacious as the pyrethrum, which came second in killing power.

6. The B.H.C. dust was distinctly less effective than the pyrethrum and cost much more.

7. Pyrethrum was specially toxic to Coccinellidæ, while Araneida, Diplopoda and Orthoptera showed signs of resistance to it. Coccinellidæ were killed only in small numbers by the other insecticides.

8. Considerable numbers of terrestrial insects were killed, specially by the sprays. The latter result is believed to have been due more to the method of application than to the inherent toxicity of the sprays.

9. Beneficial, harmful and indifferent creatures were killed, but there was no evidence of a harmful disturbance of the balance of nature during the period of the trial.

Acknowledgements

The *Lygus* insecticide trial, on to which these observations were added, was conceived by Mr. W. V. Harris, Senior Entomologist. The trial and the observations were conducted by Mr. H. D. Mubbiru, Assistant Agricultural Officer, Entomological Section, with supervision from the author in the early stages. Help is gratefully acknowledged from Messrs. A. E. B. Williams, Agricultural Officer-in-Charge, Serere; J. F. Low, Senior European Agricultural Assistant, Serere, and J. D. Jameson, Senior Botanist, and also from the Colonial Insecticide Research team at Entebbe.

TABLE I.—ANALYSIS OF COUNT OF ARTHROPODS PICKED UP

Under each treatment the first column is the number of corpses picked up in the 2 plots, except with D.D.T. spray 2, where it is the number picked up in the 1 plot doubled for comparison. The second column is the order of effectiveness of slaughter of the six treatments. In order to give the figures in this column a comparable numerical value, where, for instance, two treatments are equal fourth or together occupy the fourth and fifth places, they are shown as 4–5; if three treatments tie for the last three places they are shown as 4–6.

	Total number of individuals in all plots	Pyrethrum dust		B.H.C. spray		B.H.C. dust		D.D.T. spray 1		D.D.T. spray 2		D.D.T. dust	
A. TOTAL ARTHROPODS	919	220	2	376	1	141	3	112	4	88	5	26	6
SYSTEMATIC GROUPS:—													
B. Araneida	13	0	—	4	2	5	1	2	3–4	2	3–4	1	5
C. Diplopoda	21	0	—	4	3	0	—	10	2	14	1	0	—
D. Orthoptera	35	1	6	14	1	8	2–3	8	2–3	4	4	2	5
E. Hemiptera, all	63	20	2	32	1	8	3	2	4–5	2	4–5	0	—
F. Hemiptera, Miridae	40	9	2	25	1	6	3	0	—	0	—	0	—
G. Coleoptera, all	313	114	1	109	2	29	4	49	3	10	5	7	6
H. Coleoptera, Carabidae	84	18	3	36	1	1	5–6	28	2	2	4	1	5–6
I. Coleoptera, Coccinellidae, including larvae	72	63	1	2	3–5	2	3–5	1	6	2	3–5	3	2
J. Coleoptera, Chrysomelidae, *sens. lat.**	69	29	1	19	2	12	3	7	4	2	5	1	6
K. Coleoptera, Scarabaeidae, including 1 larva	46	0	—	27	1	7	3	10	2	2	4	1	5
L. Coleoptera, rest*	42	5	3	26	1	7	2	3	4	0	—	1	5
M. Hymenoptera, Formicidae	316	54	3	132	1	69	2	24	5	48	4	13	6
M. Hymenoptera, rest (Tenthredinidae 2, Ichneumonoidea 10, Vespoidea 3, Apoidea 5)	20	5	2	8	1	4	3	1	5–6	2	4	1	5–6
O. Diptera	123	24	2	67	1	13	4	16	3	2	5–6	2	5–6
P. Other Insects (Isoptera 2, Neuroptera (Chrysopidae) 1, Lepidoptera, including Larvae, 13)	16	2	4	6	1	5	2	0	—	4	3	1	5
ECOLOGICAL GROUPS†:—													
Q. Terrestrial Arthropods	161	18	4	66	1	11	5	52	2	20	3	4	6
R. Arthropods of mixed or doubtful habits excluding ants, for which see Line L)	80	21	2	31	1	15	3	7	4	6	5	3	6
S. Arthropods living or settling on plants	363	127	2	147	1	46	3	29	4	7	5–6	7	5–6
T. Arthropods eating plants	90	30	2	32	1	14	4	21	3	2	5	1	6
U. Same as T, excluding Chrysomelidae	21	1	3–5	13	1	1	3–5	4	2	1	3–5	0	—

**sens. lat.* in a broad sense 0 *Indet.* indeterminable (un-named).

†L. comprises Paussidae 1 corpse, Hydrophilidae 1, Endomychidae 1, Histeridae 1, Staphylinidae 14, Lampyridae (Lycinae) 3, Tenebrionidae 2, Rhysopaussidae 1, Lagriidae 2, Cantharidae 3, Curculionidae 7, *Indet.* 5.

Q. comprises Diplopoda 21, Gryllidae 6, Tetrigidae 4, Isoptera 2, Carabidae 84, Histeridae 2, Tenebrionidae 2, Coprinae 29, Aphodiinae 9, Geotrupinae 1, Scarabaeid larva 1.

R. comprises Araneida 13, Acrididae (except *Zonocerus*) 20, Belostomatidae 1, Paussidae 1, Hydrophilidae 1, Staphylinidae 14, Rhysopaussidae 1, Cantharidae 3, Coleoptera *indet.* 5, Pasammocharidae 2, Scoliidae 1, Ephydridae 18.

S. comprises *Zonocerus variegatus* L. (Acrididae) 5, Hemiptera (except Belostomatidae) 62, Endomychidae 1, Coccinellidae 72, Lycinae 3, Lagriidae 2, Chrysomelidae 69, Curculionidae 7, Rutelinae 4, Cetoniinae 2, Tenthredinidae 2, Ichneumonoidae 10, Apoidea 5, Chrysopidae 1, Diptera (except Ephydridae) 105, Lepidoptera 13.

T. comprises the following extracted from S., *Zonocerus*, Lagriidae, Chrysomelidea, Curculiodidae, Rutelinae, Lepidopterous Larvae (3).

DEFOLIATION OF CROPS BY A GEMMIFEROUS FUNGUS

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The disease described in this article is of particular interest to farmers at the higher elevations where the climate is wet and cold for prolonged periods. Under such conditions tea, coffee and eucalyptus have been found infected, while the wide range of less important plants also attacked would indicate that the majority of broad leaved crops are potential host plants. So far the disease has only been observed in two of the higher parts of the Southern Highlands Province and on one plantation at the east end of the West Usambara Mountains, both in Tanganyika Territory, but its range may be much wider.

The fungus is sterile and has no stage to indicate its systematic position among the fungi, beyond the fact that the observed *clamp connexions* in the hyphæ show it to be a Basidiomycete. It cannot therefore be given a scientific name. It reproduces vegetatively by means of small club-shaped bundles of hyphæ which are borne on leaf spots and on coffee cherries (Figs. 2 to 5). These bodies are easily detached and blown by wind to other leaves or plants on which their *infection hyphæ* grow out and infect the new leaf or plant. The name *gemmæ* has been given to such sterile bodies by A. H. R. Buller [2]. For the sake of a name, the disease may be referred to as the "Gemma-fungus disease".

A very similar fungus is known in Suriname [6], British Guiana [1, 4, 5], Trinidad [7], Sierra Leone [3] and possibly elsewhere, but that fungus bears, in addition to longer and narrower gemmæ (Fig. 6), sterile resting bodies or *sclerotia*, and because of the presence of the latter the name *Sclerotium coffeicola* (corrected from *coffeicolum*) was given to it by Stahel [6] in 1921, while the disease was referred to as the "sclerotium disease". That fungus attacks several species of coffee besides a number of other cultivated and indigenous plants.

The disease discussed here was referred to in a local publication by the present writer [8] in 1934; at that time the *gemmæ* were wrongly thought to be immature spore-bearing organs.

Conditions Favouring the Disease

Misty and cold weather following the heavy rains favour the growth and spread of the fungus. At Mufindi and Dabaga in the Southern Highlands Province, where it was first definitely recorded in 1934, a long rainy period with driving winds, lasting from mid-December to about the end of May, is followed by cold and mist. The disease commenced that year about March and continued until July or August. It was found on various cultivated and indigenous plants listed below. The cultivated areas in these districts are at a little over 6,000 feet elevation and were close to rain forest until the latter was cleared. Windbreaks of Grevillea, Mlanje cedar and wattle were grown several lines deep to shelter coffee, but their density encouraged a stagnant atmosphere favouring the fungus. Since the clearing of the forest in recent years, conditions have improved for crops, and this, together with the removal of the main source of infection in the forest vegetation, has resulted in a great diminution of the trouble.

In the other affected area, in the Usambara Mountains in the Tanga Province, the disease was not observed until July, 1948, when unusually prolonged misty and cold weather followed the heavy rains of April–May. Undoubtedly the fungus was present in the surrounding forest and the unusually favourable conditions this year encouraged its spread to a neighbouring tea garden. Climatic conditions there, however, are never so extreme as in the Southern Highlands. It is now clear from this second outbreak that the fungus is not restricted to the latter Province and that it may be found elsewhere in East Africa where conditions are similar. Farmers at high elevations near rain forest or other dense vegetation should therefore watch for any outbreak, particularly in its early stages.

In the Southern Highlands Province several plantations at a little over 6,000 feet elevation were affected, but in the Usambaras only a tea plantation, at 4,200 feet, has so far revealed the disease. The affected part of this plantation is a tea garden left to grow for seed; it is not typical of the estate as a whole. The site is a

valley, above which is forest with dense undergrowth; rain and mist had encouraged a deep growth of grass and weeds among the tea. The stagnant, damp atmosphere thus created provided the environment required for the growth and spread of the parasite. Profuse lichen growth was itself indicative of a damp atmosphere. The garden was at a distant part of the plantation, difficult for regular inspection. However, once the disease was observed, measures were taken to remove unnecessary growth and allow increased ventilation among the tea, and the trees were sprayed with lime to remove the lichen. On the estate, only one other garden showed the disease; this was in unshaded tea under plucking. Should weather conditions again favour an outbreak of the disease on such a field, the trees would be sprayed with Bordeaux mixture. The removal of undergrowth in the forest between this garden and the seed-bearers will eliminate much of the main source of infection.

Host Range of the Parasite

Tea and coffee are the only important agricultural crops so far seen affected. Both show leaf-spotting and leaf-fall which can be very heavy, but in the case of tea the youngest pluckable leaves are not affected: the damage is a weakening of the trees through loss of leaves. In forest plantations four species of eucalyptus, camphor (*Cinnamomum camphora*) and *Syncarpia laurifolia* were diseased.

Coffee was seen badly attacked at Mufindi and Dabaga, but it must be emphasized that this crop should not have been cultivated in such areas, and was in fact grown there against the advice of the Department of Agriculture. The weather was too cold and wet and the soil too acid for coffee: growth was slow, proliferation of twigs profuse, the internodes short and the foliage yellowed. The crop was quite uneconomic and was eventually abandoned. Under its normal growing conditions coffee would not be affected.

Coffee cherries become infected after the leaves and they also show spotting and the fungus *gemmæ* (Fig. 5); like the leaves they fall in large numbers.

Other cultivated plants observed to be affected in the Southern Highlands Province were: tree tomato, loquat, castor, rose, *Furcræa* sp., *Grevillea robusta* and *Cassia floribunda,* besides an indigenous species of *Bersama*. Grevillea and eucalyptus became infected earlier than coffee. Indigenous coffee in the forest was not found infected.

In the Usambara plantation a search for indigenous host plants was made only among the affected tea; the small shrub *Rauvolfia rosea* and the following weeds were seen affected: *Achyranthes aspera, Drymaria cordata, Basella alba, Cissus cyphopetala, Senecio subscandens,* three species of *Impatiens,* two ferns and single species of *Commelina* and *Aneilema.*

This wide range of hosts is not considered to indicate intense parasitism of the fungus except under the exceptional circumstances of weather and environment described above.

Symptoms of the Disease

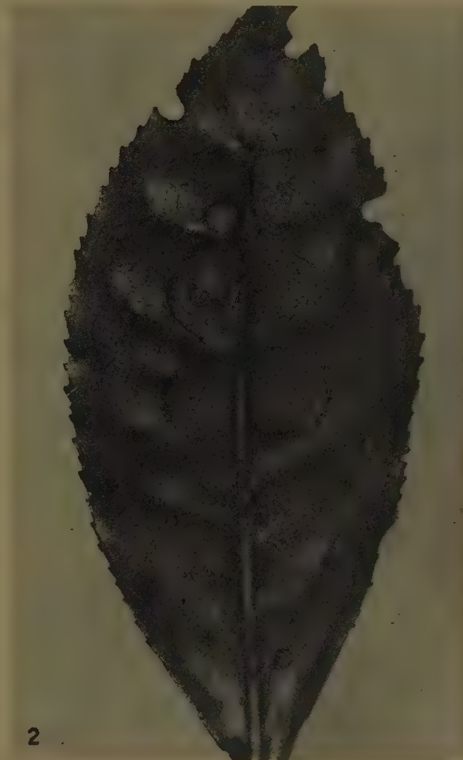
The leaf spots (Fig. 2) may be few or numerous, and each may extend to an inch or more in diameter. Several may coalesce so that half the surface of a leaf is affected. In estimates of the proportion of coffee leaves affected at Mufindi some fields showed 80 per cent diseased, with from one to fifty spots per leaf. Fresh young spots are yellow-grey or grey-brown, and usually appear water-soaked; as they dry out they become brown and have a varnished appearance. They may show concentric growth rings. The margin of a spot is definite and is often darker than the rest, especially when spread of the fungus is checked by unfavourable circumstances.

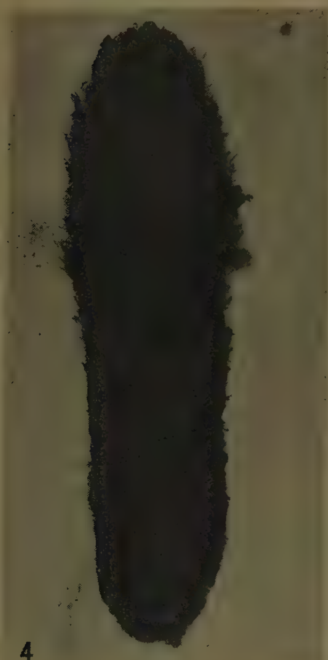
The *gemmæ* can be seen with the naked eye mostly on the under-surface (Fig. 2). When fresh they are pale, but soon turn grey or black. At first they are erect, but being constricted at the base they easily fall over; on an old spot therefore many of the *gemmæ* will be seen lying flat on the leaf.

The *gemmæ* are club-shaped or roughly cylindrical (Fig. 4), but are sometimes bifurcated at the end. The size is variable, but they are mostly under 1 mm. long. Twenty *gemmæ* from tea leaf spots were 0.65–1.14 mm. long and 0.14–0.28 mm. wide (average 0.80 x 0.21 mm.). Twenty *gemmæ* from a coffee leaf spot were very similar: 0.60–1.04 mm. x 0.12–0.29 mm. (average 0.82 x 0.22 mm.). Fig. 6 shows diagrammatically the maximum, average and minimum dimensions of *gemmæ* from Tanganyika coffee leaves, and the maximum and minimum dimensions of *Sclerotium coffeicola* of Suriname for comparison.

Before the formation of a crop of *gemmæ* on a leaf spot or on a coffee cherry, it is usually possible to see the original *gemma* which infected the leaf or cherry lying at the centre of the spot, and more often on the upper side.

DEFOLIATION OF CROPS BY A GEMMIFEROUS FUNGUS





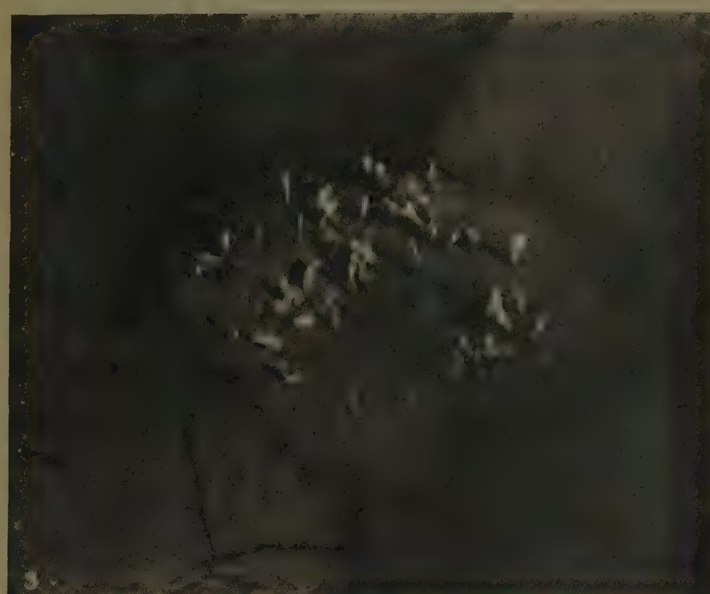
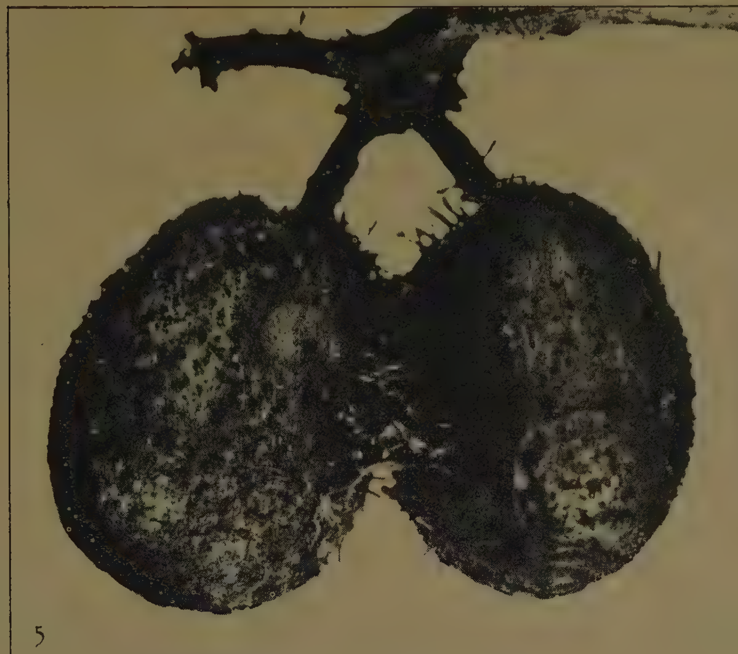


FIG. 1.—Tea twigs being defoliated by the "gemma fungus".

FIG. 4.—A single *gemma* (x 100).

FIG. 2.—Tea leaf with spots bearing *gemmæ*.

FIG. 3.—Tea leaf spot bearing *gemmæ* (x 5).



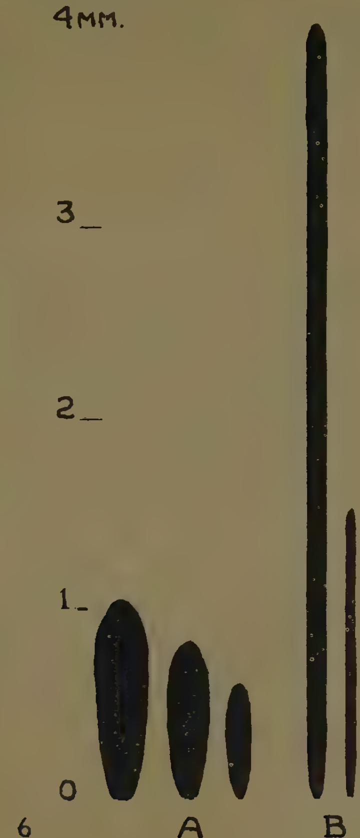


FIG. 5.—Coffee cherries showing *gemmæ* and their dark bases (x 5).

FIG. 6.—*Gemmæ* from coffee leaves in Tanganyika (A) and Suriname (B) diagrammatic. A shows the average in addition to maximum and minimum dimensions.

The tip of a fresh *gemma* is white and shows loose hyphæ when examined with a microscope; when older the *gemma* dries, shrinks and turns dark. Even when the *gemmæ* have been lost, the dark knob-like pedicels or bases on which they are borne can still be seen (Fig. 5). Pedicels have been observed to form a second crop of *gemmæ* when the original ones have been blown off. The *gemmæ* are not formed in artificial culture.

Coffee cherries can be attacked at all stages of growth. The spots are grey to grey-brown and usually appear water-soaked; they become sunken and turn black, and like the leaf spots may show zonation. The disease spreads downwards until the cherry stalk is affected, and at that stage the cherry falls. *Gemmæ* are formed in large numbers on the cherry spots, and sometimes on the stalks (Fig. 5). The disease occurs also on the twigs, but this has not been observed so closely.

As already stated, the fungus forms no resting bodies such as the sclerotia which are formed by the Suriname fungus, nor has it any spore-bearing organs.

CONTROL

Control measures have been indicated above, but are amplified below. When the disease is observed it will usually be found that there is a local reservoir of infection such as forest or permanently damp thicket. So far as possible such should be made uncongenial for the fungus by cutting out undergrowth. Having no resting stage the fungus is short-lived, and under dry conditions will die out. Its persistence can thus be checked when the forest is made more open, drier and ventilated.

Shelter belts and groups of shade trees which may be necessary for the protection of plantation trees against cold winds should not be so dense as to encourage the fungus, and in endemic areas they may require to be kept thin. Also in such areas grass and weeds should be kept cut down as they encourage a damp, still atmosphere in which the fungus flourishes. It was estimated at Mufindi that thinning of windbreaks and shade trees reduced the amount of disease by about ninety-five per cent, but this still left an undesirable amount of infection.

If the site of a plantation is favourable to the growth of the fungus in spite of these measures, it may be necessary to spray, e.g. with Bordeaux mixture, before the rains commence.

It may be that, as in the case of coffee at Mufindi, the crop is unsuited to the environment, and although a considerable measure of control of the disease can be obtained, the crop is uneconomic and should be abandoned in favour of one more suited to the conditions, possibly tea or pyrethrum.

While there is no evidence here as yet that fallen leaves and other debris can form a substratum on which this fungus can persist as a saprophyte—as occurs with the Suriname fungus—the possibility cannot be ignored, and if proved in the case of the Tanganyika fungus, such debris would require to be collected and destroyed.

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REVIEW: A PROVISIONAL CHECK-LIST OF BRITISH AND ITALIAN SOMALILAND TREES, SHRUBS AND HERBS

For the large sum of four pounds the Crown Agents for the Colonies have published on behalf of the Government of Somaliland *A Provisional Check-list of British and Italian Somaliland Trees, Shrubs and Herbs* (Including the Reserved Areas Adjacent to Abyssinia).* It was written by Major P. E. Glover, M.B.E., M.Sc., who was loaned from the Tsetse Research Department, Tanganyika, in 1944, to Somalia to undertake a detailed survey of the problems of pasture and soil conservation of Somalia. He was assisted in this work by his wife, Mrs. A. I. T. Glover, M.Sc., who is herself a trained botanist and by Captain H. B. Gilliland, B.Sc., F.L.S., a lecturer in Botany at the Witwatersrand University.

This 446 page book, containing 13 plates of vegetation photographs of Somalia with a vegetation map with two profiles, is apparently the first of a series of four volumes and is a compilation of plant names, both botanical and vernacular Somali. It also covers the vegetation in part of the Ogaden Province and the Reserved Areas. The second volume will deal with root systems and the general ecology of numbers of plants, and the third with the different practical aspects of the devastation of the grazing areas of Somalia. The fourth volume will contain Captain Gilliland's report on the grazing areas of the eastern part of the Protectorate.

The Provisional Check-list, Volume I, opens with a foreword by Brigadier G. T. Fisher, C.S.I., C.I.E., Military Governor of British Somaliland who gives an account of the inception of the Glovers' and Gilliland's work.

Like most people who wish to study vegetation as a whole in East Africa, Major Glover was confronted by the lack of a proper flora of his area by means of which he could identify the plants. It was, therefore, necessary for him to prepare an inventory. This volume is the result of his search through some 31 books and manuscripts, through a herbarium of plants collected by J. B. Gillett, botanist on the British-Italian Boundary Commission of 1932, and a MS. check-list compiled by Major E. T. Peck, at one time Veterinary and Agricultural Officer in British Somaliland.

The preface consists of some seven pages, part of which deals with botanical synonyms and the confusion that arises regarding the correct nomenclature to apply to many plants. Unfortunately as an example Major Glover quotes extracts from an East African biological journal "To illustrate what is meant by 'Synonymy'". It is obvious to anyone with a knowledge of botanical nomenclature that the original author of the article quoted had no knowledge of the subject whatsoever. The examples he gave made confusion worse confounded and instead of clarifying the problem of what a botanical synonym is he made it more confused than ever by the examples he quoted.

Three lists of collectors who visited Somalia are given. The first two also state the years when they were in the country. The third gives a list of names only, as no further details about the collectors were available at Burao.

The introduction, consisting of eleven pages, describes the position of British Somaliland, climate, phytogeography and botanical linkages, and gives "Brief Notes on the Main Vegetation Types" of which the author recognizes twelve, from "Coastal Haloseral Vegetation, Mangroves" to "Juniperus Forest Relics". Three native vernacular names are used for three of the types, "*Nogal* Vegetation"; "*Haud* Subtype Commiphora, Acacia Tree and Shrub"; "*Haud*-Commiphora, Acacia Tree, Shrub and Grass" and "*Tug* Vegetation" the last named not included in the twelve types but described as "More or less common everywhere, irrespective of altitude, although each type contributes a few distinct species to the riverine vegetation within its own range". Unfortunately the author does not define what a *Nogal, Haud* or a *Tug* is. They do not appear to be plants as they are not to be found in the list of vernacular-botanical names on pages 329–432.

The introduction is followed by a "Note for Officers Using this Provisional List" then the main body of the work commences with a Bibliographic Index To Families, most useful to those who do not know their way about Oliver's *Flora of Tropical Africa*. I think, however, some nine pages could have been saved from an already fat tome by including such references under each family or genus in Part I Botanical-Vernacular Names of the work instead of only a few, for example, Papilionaceae, pp. 205–218.

* P. E. Glover.—*A Provisional Check-list of British and Italian Somaliland Trees, Shrubs and Herbs* (including the Reserved Areas Adjacent to Abyssinia, pp. 1–28 and 1–446, 13 plates, Vegetation Map with two profiles. Price £4. The Crown Agents for the Colonies, 4 Millbank, London, S.W.1.

Next comes a 47 page Index to Genera and Synonyms where it is difficult to tell which is the correct generic name when you get such entries as "*Acacia* (Mimosaceae) Part 1, p. 188" followed by "*Acacia* see *Albizzia, Dichrostachys*", or *Acanthus* (Acanthaceae) Part 1, p. 59" followed by "*Acanthus*, see *Blepharis*". The generic name *Acacia* is a valid botanical name, it is not a synonym of *Albizzia* or *Dichrostachys* both of which also are accepted generic names. The same applies to *Acanthus* and *Blepharis*.

The Check List proper is divided into two parts, Botanical-Vernacular Names, Part I Dicotyledonae; Botanical-Vernacular Names, Part II Monocotyledonae; these comprise a further 270 pages of the book. In this section the families are arranged in an alphabetical sequence as are the genera and species. Here the author has gone to an immense amount of time and trouble to quote synonyms whether they are correctly applied or not. As an example, under *Ficus capensis* Thunb. p. 195, the author lists 33 figs which he says are all synonyms of *F. capensis*. This list is four lines short of a full page of the book and appears to have been extracted from the *Flora of Tropical Africa* vol. 6, 1, pp.101–103 (1916). As few of these synonyms have been used in the scanty literature on the Somaliland flora why bother to quote them? Anyone with a knowledge of the flora of Africa knows he can find an abundance of fig names merely by consulting the *Flora of Tropical Africa* or, for that matter, the *Index Kewensis*.

In the Leguminosae the author not only gives under the families, but also under the genera references to E. G. Baker's *Leguminosae of Tropical Africa*. Under the Gramineae however, no reference to the *Flora of Tropical Africa* is made at all, though this part of a Flora (commenced in 1868 and not yet completed) is the most recently published as Vol. 9, Part 1, dealing with some of the Gramineae appeared in July, 1917, and Part 6 in January, 1934, while Part 1 of Vol. 10, appeared in May, 1937.

Pages 329 to 432 contain an alphabetical list of Vernacular-Botanical Names. At the beginning of this section is a list of the names with their abbreviations of twelve people who are listed as authorities for the Somali vernacular names. Some of the vernacular names like those in Swahili appear to be "blanket" names applied to a number of species of similar characteristics, whilst others cover such distinctive plants as trees, *Commiphora* spp. and eleven genera of grasses as represented by the vernacular *Agar*. The name *Balambal* is repeated eleven times for seven widely separated genera and *Balanbal* eight times for six diverse genera of which the same species are found under *Balambal*. I know it is difficult to settle the correct spelling of words in native vernaculars, but reference to a Somali scholar should have shown whether the word should be spelt with an *m* or *n*.

The book concludes with an appendix containing interesting notes on such items as Khat, *Catha edulis*, a stimulant narcotic; Waba, *Acokanthera Wabajo*, an arrow poison, etc. Lists of zoological names in English, scientific and Somali vernaculars are also given. There is also a bibliography and two lists of Addenda and Corrigenda.

The thirteen plates, some of them containing two photographs illustrate the main vegetation types as well as that of *Tug*, described in the earlier pages of the book. They are excellent and give one a very good idea of some grim looking country.

The diagrammatic map, on a scale of 1:1M., of the distribution of the vegetation types of British Somaliland should be of value in linking up with other vegetation maps of other parts of Africa. It will also be useful should a vegetation map be prepared for the whole of Africa.

There are also two profiles of the vegetation types, these are superposed on diagrammatic sections showing the geological structure of British Somaliland. They do not indicate however, what portion of the vegetation map they cover.

The book is one that everyone who is making a study of the flora and vegetation of Africa will have to have on his bookshelf as a work of reference. Whether the professional taxonomists will find it an unmixed blessing when they come to write the flora of East Africa, now contemplated, it is hard to judge.

The author is to be congratulated on a very painstaking and difficult piece of work, undertaken in British Somaliland where he must have been constantly hampered by the lack of a library and an extensive herbarium, facilities that would have been at his disposal had he worked in Europe. One cannot help but wonder if this intensive industry was really necessary when E. Chiovenda's *Flora Somala*, Vols. I and II (1929 and 1932) had already been published. There is also J. B. Gillett's paper, "The Plant Formations of Western British Somaliland and the Harar Province of Abyssinia" in the *Kew Bulletin*, 1941, pp. 37–199. The author refers to both of these works.

P.J.G.

A FURTHER NOTE ON THE SEPARATION AND DETERIORATION OF THE COMPONENTS OF PYRETHRUM FLOWERS

By V. Croome, Hon. Secretary, Pyrethrum Board of Tanganyika

(*Received for publication on 27th September, 1948*)

In his article on the above subject, Hopkins suggested that further work was necessary "to study the practical possibility and the economy of baling pyrethrum achenes as opposed to whole flowers", having noted considerable interest recently in developing a more logical way of transporting and exporting the toxic components of the pyrethrum flower than as whole flowers.

It may therefore be of interest to report briefly the work of two growers in Tanganyika during the last two years, who, appreciating the advantages to be gained by growers and processors of marketing only the essential parts of pyrethrum flowers while preserving their full toxicity, set to work to develop an economic method of doing so. It is probably the inevitable rumours arising from the promising progress of this work that account for the "interest" noted by Hopkins.

Thanks to the friendly relations existing between the Pyrethrum Boards of Kenya and Tanganyika, the report of Hopkins and Gaddum was passed to these growers in Tanganyika, and later they were able to see one of the bales concerned. As a result they were still inclined to take the opposite view to that held in Kenya, and to be encouraged rather than depressed by the experiment! At this time they were well advanced with their processes, and had taken out patent coverage on their methods.

From their own work they were in an excellent position to explain where they thought Hopkins' report was misleading. The main features were that Gaddum's separated product could not justly be described as even reasonably cleaned achenes + florets (much less as the high-content achenes alone), nor could it have been baled in such a press as described to any pressure comparable to that of a pyrethrum flower baler. As regards the first point, had his product been the achenes + the florets cleanly separated from flowers of 1.3 per cent content it should have analysed at over 2 per cent, but did not, by any method of analysis. The point has since been discussed with such an expert as Mr. Beckley, who agreed that the content of the achenes + their florets from 1.3 per cent flowers would be not less than 2.06 per cent. As regards the second point, the "bale" was in fact a loose crumbly cake in which no baling effect had been achieved, but the optimum conditions for deterioration had been set up. On inspection it was found, as expected, that the product was a mixture of achenes, florets, scales, and broken cups and petal matter.

However, even under these conditions the loss of pyrethrins in storage, though of course greater in the separated product than in the whole flowers, did not show anything like the disparity feared hitherto; it had been thought that separated products might deteriorate as much as twice as quickly as the flowers from which they came. The anti-oxidant treatment has never been favoured in Tanganyika when considering the possible control of deterioration in separated products of pyrethrum flowers as it was considered to be expensive and unlikely to prove more than a palliative, and the aim was complete stabilization. It is not known what anti-oxidant was used by Hopkins, but that it proved a reasonable palliative is shown by his experiment.

The present custom of marketing whole flowers when practically all their value is contained in the immature seed comprising their centres is obviously open to criticism, so the difficulties to be overcome before marketing only the valuable components are worth examination. They can be summarized as follows:—

(*a*) The separation and the cleaning of the components desired from the flowers must be nearly 100 per cent efficient to be economical.

(*b*) The deterioration in the separated product must be no more than in whole flowers.

(*c*) There must be a market for the separated products.

Tackling these problems in that order in Tanganyika their solution is now in sight.

Complete separation of the achenes and florets is achieved many times a day by every grader of pyrethrum. He merely squeezes and rotates a dried pyrethrum flower between finger and thumb and the achenes drop into his palm! One hundred per cent recovery can be achieved by an African child the same way, but his output is only about 1½ lb. per day, so the method is uneconomical. To do the same thing mechanically to the same pitch of efficiency has necessitated the invention of a machine, but this has now been achieved and the recovery claimed is almost as good—99.9 per cent. The product of this machine has, however, to be cleaned, and though there are difficulties also in this operation it is now only a matter of striking a balance between the desired degree of cleanliness and the expense and simplicity of the apparatus. Well over 90 per cent cleanliness presents no difficulty now, but whether the last few hundredths are worth the further trouble involved is simple a matter of economics—at any rate there is no insuperable problem in it.

Although the separated product is more susceptible to deterioration than whole flowers it is in fact much easier to treat with anti-oxidants and the like by virtue of its homogeneity. Flowers themselves are not free from deterioration and in certain conditions, e.g. when loosely baled or when fully mature (and so at their maximum content), are liable to lose 20 per cent or more content between farm and buyer. Even when picked, dried and baled in optimum conditions and treated with anti-oxidants a loss of some 5 per cent is anticipated. The separated product has therefore not a very high standard to beat. Due to the fact that the product lends itself so readily to baling, it is possible to bale it far more compactly than flowers in the same press and thus gain more than flowers do from the anti-deterioration effect of such baling. The application of anti-oxidants, if desired, can be expected to be the more effective on the homogeneous baled mass of the product than on the uneven array of interlocked flowers. To stem the deterioration in the separated product to the same or better degree than in flowers would not appear to be a problem at all. But complete stabilization is the ideal, and the physical form of the separated product again lends itself to any treatment aimed at achieving this end. Trials and experiments are in hand continuously but, of course, have to await the passage of time to allow of deterioration before results are obtainable, and require considerable chemical facilities. From results to date (a treated sample has lost 1 per cent in six months whilst its untreated content lost 19 per cent) it is already clear that the solution of the problem is in sight, and that though it may take a long time to arrive at the ultimate most suitable and economic treatment, there is no longer any room for doubt that the same degree of success as with the other problems has been achieved.

At first sight one might be justified in thinking that buyers would immediately jump at the pyrethrins they want being offered to them in a more concentrated form. With no increase in overheads their plants should apparently extract much more from the same bulk of raw material. But they may have problems of their own to solve in developing a technique for dealing with such an advance in content. All the indications are that they will appreciate the potentialities of the separating and stabilizing processes that have now become a practicable proposition, and that they will not be long in adapting their extract plants to deal as efficiently and profitably with the new products as they have hitherto with flowers.

The Pyrethrum Board of Tanganyika have entered into an agreement with the inventors and patentees of the processes referred to above whereby the exploitation of the products of the processes in Africa will be undertaken in future by the Board. It is not too much to hope that the introduction of the processes at this time will materially help the growers in their efforts to rehabilitate, expand, and make profitable again their industry, and by so revolutionizing the marketing of pyrethrum re-establish it once more as a leading dollar-earner of East Africa.

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ARTIFICIAL INSEMINATION IN CATTLE BREEDING IN KENYA

By J. Anderson, Experimental Station, Naivasha

(*Received for publication on 6th November, 1948*)

The development of artificial insemination provides one of the best examples in our time of the impact of science on practice and of the stimulus to each which the interaction creates. It has fostered much intensive study on a variety of problems of male and female fertility which has led to a considerable increase in our knowledge of reproductive processes. Progress and success in artificial insemination has been greatest in those countries in which active fundamental and applied research work on problems of reproduction has been done and we in Kenya have been fortunate in having facilities for this work and also in having the willing co-operation of many farmers in testing out ideas on a large scale in practice.

The basis of artificial insemination is that in normal mating the bull ejaculates many more spermatozoa than are required for conception. A mature bull ejaculates approximately 5,000,000,000 spermatozoa (volume, 5 ml.; density, 1,000 million per ml.). Although the minimum number required for fertilization has not yet been clearly established, normal conception rates have been obtained with dilution rates as high as a hundred times. A fertile bull should produce not less than 100 ejaculates per annum, so it is quite obvious that a bull is capable of siring very large numbers of progeny; in fact, bulls are reported to have sired up to 6,000 calves in one year. One of the drawbacks of such high dilutions is that such sperm keeps less well on storage, but there seems little doubt that this difficulty will be overcome, enabling very considerable use to be made of bulls.

From a consideration of these facts it is clearly obvious that considerable genetic improvement in our cattle might be brought about by the extensive use of outstanding bulls. Artificial insemination as compared with natural mating may change the genetic composition of the next generation in either or both of two ways: (1) by decreasing the fraction of all males born which are to be used as sires and (2) by improving the accuracy with which the breeding values of the potential sires are estimated at the time of deciding whether to use them or not. Artificial insemination as compared with natural breeding can make large changes in the former, but only small changes in the latter. How much the rate of genetic improvement of the dairy population will be increased by these changes can be appraised on the basis of what is known about: (*a*) the amount of genetic variability in the population, (*b*) the correlation between estimated and actual breeding values of sires, and (*c*) the amount by which the estimated breeding values of the selected sires exceed the average breeding value of all males born.

One of the economic consequences of artificial insemination will surely be a reduction in the number of bulls on farms and correspondingly more cows on the farms where bulls are no longer required. Improved feeding and management practices will come through the better keeping of records and contacts with technicians. The health and fertility of animals should improve along with the genetic make-up of herds. The primary problem of artificial insemination is to speed up the rate of live stock improvement and to accomplish this sires that are genetically superior to the females to which they are to be bred must be used.

In England, the Milk Marketing Board is primarily interested in an artificial insemination service as a means to a very important end. By the Act under which it operates the Board has a duty to the consumer constantly to watch and seek ways to improve the efficiency of milk production on the farm and in this process improved breeding is the corner stone. It is stated that from a pedigree analysis of the 70 bulls owned by the Board and from a knowledge of the level of production in the herds using these bulls, a prediction of an increase of 100 gallons per cow in quantity and 0.2 to 0.4 per cent in butter-fat content in quality would seem to be conservative.

An important point is that these superior bulls must be used in a breeding programme adapted to the farmer's locality, i.e. that adaptability must be considered when the technique is used in areas where the environment imposes limitations on live stock production. There has been much talk about using artificial insemination to introduce improved stock

quickly and on a large scale in countries or areas where the existing animals are relatively unproductive, but if the animals are unproductive because of the conditions imposed by nature, the widespread introduction of improved stock from favourable environments may be a hazardous undertaking.

A Central Artificial Insemination Station was established at Kabete in 1946, to provide primarily for the small and medium-sized dairy herds, whereby first class bulls selected for their breeding, are available at low cost. Sperm is available from pure-bred Ayrshire, Friesian, Guernsey and Jersey bulls and is supplied to the Limuru and Kitale Cattle Breeders' Association and to the European Settlement Board at Konza and Elmenteita, where it is handled by fully-trained inseminators. The amount of sperm sold directly to farmers who carry out their own inseminations is relatively small—about 17 per cent. For many districts the best and most economical method will probably be the setting up of sub-stations which will receive sperm several times a week from the Central Station in quantities to meet the demand. In some areas it will be practicable to employ the services of a lay inseminator and judging by the experience of the district associations, where the best results have only been obtained by trained inseminators under competent veterinary supervision, this will be infinitely the better method.

The longest routine period of travel that Central Artificial Insemination Station sperm undergoes at present is 24 hours to the Kitale Station and satisfactory results with this sperm are being obtained there (2.1 inseminations per conception). Recently 24-hour old sperm after a rail journey of a 100 miles has been used to inseminate 600 Zebu heifers and 50 per cent conceived to the first insemination. Semen has been supplied by air from Kabete to Dar es Salaam and there is a possibility of a limited service to other areas in East Africa. There should be no great difficulty in transporting sperm by air from Britain to Kenya, but this service will probably only appeal to the pedigree breeder. Bull semen has been successfully transported across the Atlantic from New Jersey to Italy; in January of this year over twenty calves were born from this semen. The longest shipment on record, however, is that from New Jersey to Sydney, Australia, via Egypt, a distance of 16,000 miles, resulting in the pregnancy of several Jersey cows.

The main breeding practice with European-owned cattle in Kenya is to grade up by the use of pure-bred sires and it is established that high-grade and pure-bred cattle can be kept successfully in the Kenya Highlands. The Central Artificial Insemination Station, by judicious choice of bulls and by insuring proper organization and handling of sperm at the receiving end, can play a big part in the genetic improvement of dairy cattle in Kenya.

If the beef industry is to be developed to any extent in Kenya, the use of colour-making beef bulls, such as the Hereford, for the production of calves for rearing and feeding into beef might well be instituted as in Britain; the procedure would be limited to the production of good beef steers from dairy cows that are unsuited to produce dairy replacements.

In Kenya we have most of the problems met with in other countries and a few more as well, due to local conditions. There is need for much fundamental research into the physiology and pathology of animal reproduction, into animal genetics and into the big subject of adaptation. The subjects of animal reproduction and adaptation have a definite relationship to each other for reproduction is much influenced by environmental conditions —climatic, nutritional and so on—and since reproductive functions are influenced by varying environmental conditions they may serve as an index of the relations between an animal and its environment. A considerable amount of knowledge on these and related subjects has been acquired in Kenya, but useful though this is it points to further gaps in our knowledge. For instance, we know that seasonal variation in the reproductive functions occurs in both the bull and the cow; sexual function on the whole being increased in December, January and February and September and decreased in May, June, July and November. It appears that climatic conditions at these seasons stimulates or depresses body metabolisms, as the case may be, and this is confirmed by a study of a constituent of the blood, cholesterol, which varies inversely with the body metabolism. Metabolism is largely influenced by the thyroid gland, so the thyroid may play quite a big part in this picture. In the absence of the thyroid gland the normal sex urge is absent in the bull and the production of semen may be seriously affected, and cows do not come on heat. It is well known that cows in Kenya have very short heat periods and it is quite likely that this may be due to a low level of thyroid activity. Means

of lengthening the heat period and hence the ease and reliability of picking out cows for artificial insemination would be of the greatest help in improving breeding efficiency.

We need still more information about many aspects of insemination technique, such as the best time and best place to deposit the semen in the cow, better methods of storing sperm, higher dilution rates, assessment of potential storage capacity of sperm, assessment of male fertility and, in the field of bull psychology, much remains to be done on sex behaviour. This last subject is of particular importance in Kenya, for the sexual lethargy of the Zebu bull will impose a practical limitation on his use for artificial insemination. There remains the field of research in animal genetics, in which little has been done in Kenya. Artificial insemination breeding policies and methods of bull selection have not so far made a great break with tradition. The commercial user of artificial insemination requires bulls that will maintain or improve the production of his herd and the use of bulls carefully selected by present-day methods should suffice. Artificial insemination centres can act as field laboratorian for the animal geneticist and should provide extremely valuable material for examination of breeding policies and methods of bull selection.

REVIEW

PHENOTHIAZINE, 1942–46, A Review and Bibliography, By J. Tweedale Edwards, M.R.C..V.S., and The Imperial Bureau of Agricultural Parasitology (Helminthology), November, 1947, pp. 35. Price, Sh. 4. Central Sales Branch, Commonwealth Agricultural Bureaux, Penglais, Aberystwyth.

J. Tweedale Edward's "Phenothiazine, 1942–46" is a comprehensive paper fulfilling a very useful purpose, for it summarizes the great mass of work which has been recorded from all over the world on the use of Phenothiazine as an anthelmintic and gives a complete and up-to-date bibliography.

The compilation first reviews the pharmacology and toxicology of the drug and goes on to the clinical application of phenothiazine in veterinary practice. This main part of the paper is prefaced by a general section on methods of administration and is thereafter divided into sections dealing with the use of Phenothiazine for each type of animal separately. The dose rates used and the efficacy of the drug for the various types of worm harboured by the animals in question are listed.

The review of literature on the administration of Phenothiazine to sheep as a lick is perhaps of special interest in this country, as is also the reference to blindness in calves caused by the drug. The latter condition is known to occur in East Africa. The dose tables for fowls and horses are of great value to East Africa where the drug has already been used extensively in these animals.

Finally, this publication is most complete and comprehensive, covering all aspects of the uses of Phenothiazine as an anthelmintic for farm live stock.

B. L. D.

SOME ASPECTS OF THE TERMITE PROBLEM

By W. Victor Harris, Senior Entomologist, Department of Agriculture, Uganda

(*Received for publication on 3rd December*, 1948)

The termites, or white ants, are a group of insects widely distributed throughout the tropics, present in much of the sub-tropical zone and even reaching some parts of the northern and southern temperate zones. As one of the older orders—they spring originally from the primitive cockroach stem—they have had ample opportunity to evolve along a number of widely divergent paths, with the result that among the two thousand different species known to exist there is considerable variety in their way of life, not least in their feeding habits and the construction of their nests.

Most of the detailed work in termite biology has, up to the present, been carried out in America and Australia. Unfortunately, much of this work does not apply to Africa, because the dominant groups in those two areas, especially when considered from an economic standpoint, are quite different. Africa, south of the Sahara, has the largest number of species of any of the major geographical zones, and is the main home of those termites which grow fungus gardens in their nests. Fungus-growing termites provide exclusively the large mounds, or ant hills, which are so typical of tropical Africa outside of the Congo rain forest. While fungus growers are present in India, they are on the whole much less conspicuously a part of the landscape. Only in Siam and Malaya do they appear to compare with the African species in their mound building. In Australia mound building, some of it on an almost African scale, is the work of non-fungus-growing termites whose African relatives build only low hummocks in seasonal swamps and grassland. In America, mound building is on a reduced scale and fungus growing non-existent. Fungus growing is a habit with a profound influence on termite biology. In contrast, the primitive damp-wood termites are well developed in America, and to a less extent Australia, and their economic importance in attacking buildings, woodwork generally, and growing trees has led to their study in great detail. While by no means absent from Africa, damp-wood termites are uncommon and but seldom of economic importance. *Coptotermes amanii*, the "dry rot termite" of buildings on the East African coast is not a true damp-wood termite but provides one of the few examples of this type of damage that we have. In the Far East species of *Coptotermes* are, in addition, serious pests of tea, rubber and other plantation crops. Of the 45 species of termites in the United States of America, 21 are true wood-infesting termites with no connexion with the ground, while a further ten species belong to the intermediate group of subterranean-nesting wood-feeders related to *Coptotermes*. It follows that American work is focused on groups which here in Africa are not of primary importance.

Sjostedt's catalogue of the African termites published in 1926 lists 491 species, made up of the following:—

Harvesters	16
Damp-wood termites	43
Subterranean-nesting wood termites	16
Soil-dwelling termites (including mound builders and fungus gardeners)	416

Since that time 50 new species have been described, making a grand total of 541, while many more await description. Cosar (1934) has searched diligently through the writings of African travellers for references to termites, and discusses briefly their geographical distribution by countries and in relation to climate, vegetation and soil. He deals in addition with the influence of termites on landscape, their role in native life, and termite damage and benefits to the white settler. His general conclusion is, however, that although references to termites are numerous in general works on Africa, the questions of primary interest to the geographer—distribution, ecology and economic status—have virtually not been touched.

Termite Biology

Out of a total of 541 species of termites recorded in Africa south of the Sahara, 81 are represented in published lists from East Africa (Harris, 1936, 1941, 1948). Unpublished records and unidentified specimens in the writer's collection indicate that many more species will be added to this total. The actual number of species recorded from individual territories (Tanganyika 51, Uganda 25, Kenya 19 and Zanzibar 11) is more an indication of intensity of collection than of faunal pattern.

It detracts in no way from the excellent work done by visiting scientific expeditions—Von de Decken, Sjostedt, Allaud and Jeannel to name but a few—to suggest that future work on the termite problems of immediate interest to East Africa will need to be on living insects, and not on specimens preserved in museums in another continent. Systematics is the foundation of biology and, while traditionally connected with museums, would benefit by closer contact with the living insect. Furthermore, it is time to turn from rapid collecting over wide areas, to the detailed combing of selected localities, so that accurate knowledge of the distribution of species —especially the more common ones—may be obtained. At present, discussion of geographical distribution is hampered by lack of knowledge of the fauna of wide areas, especially in the negative aspect that no report means absence of a species. For example, a species of *Capritermes* has recently been found in Central Tanganyika, although this genus with conspicuously asymetrical jaws had hitherto been considered as restricted to West African rain forest on the basis of known records.

Little is known of the biology of East African termites except for a few species which have been studied elsewhere on the continent. Our fauna, being predominantly soil dwelling, is not easy to study, but the need for such a study is none the less pressing if the ecological and economic problems associated with them are to be solved. The large mound-building *Bellicositermes* spp., and the small mound genera *Cubitermes* and *Eutermes* are literally conspicuous in this respect. The feeding habits and digestive processes of the various groups of termites require investigation, as a likely source of explanation for much of their activity which may be termed "economic".

Termites and Soil

There is general agreement about the destructive powers of termites as a group, especially with regard to their attacks on timber. On the other hand, there is a feeling that the soil-nesting members of the group, at least, have a useful function in promoting soil fertility. This idea of termites having a beneficial effect on soil was advanced by Henry Drummond (1888) in his book on travels in Nyasaland and Northern Rhodesia. Inspired by Darwin's "Vegetable Mould and Earthworms", Drummond "would humbly bring forward another claimant to the honour of being along with the worm the agriculturist of nature". He continues:—

"Let me now attempt to show the way in which the work of termites bears upon the natural agriculture and geology of the tropics. Looking at the question from the large point of view, the general fact to be noted is, that the soil of the tropics is in a state of perpetual motion. Instead of an upper crust, moistened to a paste by the autumn rains, and then baked hard as adamant in the sun; and an under soil, hermetically sealed from the air and light, and inaccessible to all the natural manures derived from the decomposition of organic matters—these two layers being eternally fixed in their relation to one another—we have a slow and continued transference of the layers always taking place. Not only to cover their depredations, but to dispose of the earth excavated from the underground galleries, the termites are constantly transporting the deeper and exhausted soils to the surface. Thus there is, so to speak, a constant circulation of earth in the tropics, a ploughing and harrowing, not furrow by furrow and clod by clod, but pellet by pellet and grain by grain."

This theory of termite behaviour was later developed into a paper with the explanatory title "The Termite as the Tropical Analogue of the Earthworm". Drummond's views appear to have got themselves firmly fixed in the general mind.

In some localities termite mounds are cultivated by peasants in preference to the surrounding land. In other areas, termite mounds are avoided and by their presence reduce the effective productivity of the land. Griffith (1938) found that in certain Uganda termite mounds the organic matter was less than in the surrounding soils, but that the available inorganic nutrients were more in some cases and less in others. In Siam, where the abundant large termite mounds are frequently cleared of vegetation and planted with crops, Pendleton (1941) found them to be generally of heavier material than the surrounding surface soil, with a neutral or basic reaction while the soils about the mound are often quite acid. He states that the principal chemical difference is that in the base of the mounds there are considerable accumulations of calcium carbonate. The presence of lime nodules in East African termite mounds was reported by Milne (1938 and 1947). As sources of

agricultural lime such mounds may possibly be of value, but it is not safe to make any general recommendation for their use since it is known that over large areas of East Africa no termite mounds have been found that contain lime nodules. Incidentally, the origin of lime accumulations in termite mounds is obscure. Pendleton remarks "Milne's guesses as well as our own as to what the possible mechanism or process may be seem too fantastic to repeat here. And Professor Light agrees that all attempts to explain accumulation of calcium carbonate seem ridiculous".

Where large mounds are numerous, they may form a not inconsiderable proportion of the ground surface. Their disposal for aesthetic or practical reasons—and the progress of mechanical cultivation has brought the latter into prominence of late—is a matter which cannot lightly be undertaken. Apart from the cost of breaking up mounds which contain several tons of earth, their disposal is a problem if their fertility is less than that of the surrounding soil. A further complication, the influence of the age of the mound on its soil structure, is noted by Morrison, Hoyle and Hope-Simpson (1948) in their work in the south-western Sudan. They conclude: "these inconclusive arguments are worth bringing forward because they show something of the complex soil problem involved in the ageing of termite mounds—a problem likely to be solved only by a study of mounds in considerable numbers". The physical difficulties of excavating large mounds in sufficient numbers has prevented this aspect of the termite problem from being studied in East Africa. It is known that the building of a new mound can proceed with surprising rapidity, but nothing is known of the mound in decline. In certain areas the large mounds which dominate the landscape are all uninhabited by their original builders and remain like models of some Maya settlement in Central America, a monument to a vanished population. A further practical problem in the clearing of mound-building termite is the cheap and efficient destruction of the colony, in order to ensure that rebuilding of the mound will not render the work in vain.

Observations in progress on the mound-building habits of *Bellicositermes natalensis* in Uganda indicate that these large bare mounds are built rapidly from soil particles collected below the level of the top soil and down to six or nine feet. The construction proceeds with no more disturbance of the top soil and its vegetation than arises from the opening of a number of shafts, and the subsequent overlay of several tons of sub-soil. Below the surface, however, extensive excavations in the form of small tunnels spread out from the nest to provide suitable building material. It appears that the large African mound builders do not make great use of digested soil in their building operations, but rely on soil particles cemented with saliva. Small mound builders, on the other hand, work almost entirely in top soil, and make their mounds from humus-free digested soil. The resulting mound material is similar in both cases, in so far as in one the soil is collected free from humus, while in the other the humus is removed by passage through the insect.

Reference to digestion brings us to the question of the role of termites in the accumulation of humus in the soil. Referring back to Drummond we see the origin of the "earthworm theory" and the idea that termites keep up the cycle by which plant residues are returned to the soil. While there can be no doubt about the ability of termites to dispose of plant residues, it is the opinion of the writer that they carry the process too far for the ultimate benefit of the soil. The fungus-growers collect undecomposed woody material over a wide area and concentrate it in their nests in the form of fungus gardens. This material is removed out of the range of smaller organisms, and so far analysis of mounds has failed to show any increase in soil fertility as a result of the use of so much plant material. The harvester termite has its nest several yards below the surface, so that any products derived from the grasses it collects are far removed from the top soil. The dome-building *Cubitermes* and *Nasutitermes* use for part of their food requirements the organic matter present in the top soil. Their mounds are made from faecal matter, that is soil freed from humus during its passage down the termite's alimentary canal, together with the residues from their other food-dried grass and herbs, which in the strict economy of the colony will be mainly inorganic. While it is possible to reduce the numbers of dome-building colonies in an area owing to their superficial nature, it is not possible to do this with the fungus growers, at least by mechanical methods. Two possible lines of attack on the problem of getting organic matter back into the soil without loss from termites are,

first to determine the degree of composting necessary to make the cellulose of no further use for fungus gardens, second to investigate the termite-repellent action of certain new insecticides the use of which would permit decomposition of the vegetable matter without interference by termites.

Termites and Vegetation

The relationship between termites and vegetation, while diverse and complicated, falls into two divisions. The first of these is ecological and derives from the problem of termites and soil fertility, being broadly speaking the effects produced on the flora by local changes in soil type and situation resulting from termite activity. Troll (1936) describes in general terms the development of what he calls "termiten-savannen", one of his examples being taken from the Southern Highlands of Tanganyika. More recently Morison and others working on soil-vegetation catenas in the south-western Sudan have studied in some detail the effect on vegetation of termite mounds. In the area in which they worked, termite activity, they consider, has profound effects and in conjunction with annual grass fires, cultivation and erosion plays an important role in the development of eluvial woodland. Their further conclusions that the precise relation between the vegetation of termite mound soils and that of the surrounding shallow soil-phases requires more intensive and thorough investigation, and that the vegetational successions can be adequately studied only by workers with facilities for continued observation and a knowledge of termites as well as of soils and vegetation, apply equally well to East Africa.

The second aspect of the relations between termites and vegetation is economic and concerns the question of termite attack on growing plants. Some people are convinced that termites do not attack healthy plants, at any rate in Africa, and that any termite damage is simply an indication of primary ill-health. There is no doubt that the amount of damage done by termites to crops, whether it be regarded as primary or secondary in nature, is small compared with the population of termites in most areas. This appears to be due to the small part played by damp-wood termites in Africa. In dry areas grazing may be attacked by the harvester termite, giving rise to noticeable losses of grazing in the dry season and exposing the soil to erosion by the first heavy rains. The harvester termite is regarded as a pest in South Africa and in parts of Kenya. Sufficient records of attacks on annual crops by the large mound-building *Bellicositermes* and subterranean nesting *Termes* and *Microtermes* (all fungus growers) have been accumulated to suggest that the "healthy plant" theory is at least an over-simplification of the question. There may be some relation between the attack on annual crops such as cotton, tobacco and maize, and the depletion of organic residues in land cleared from bush after a year or two under cultivation. Annual crops, garden plants and lawns can be protected from damage by termites by the use of repellent insecticides in the soil, though further work is required to make this an economic proposition in most cases. More desirable would be the adoption of agricultural methods which would sidetrack the termite from the crop.

Termites and Soil Erosion

The part played by termites in furthering soil erosion arises from the foregoing discussion, especially on three points. These are first the bringing to the surface of soil which is free from organic matter and hence lacking in resistance to erosion by water and wind. Secondly, by depriving the surface soil of humus by digestion or by removing organic matter which otherwise would have been incorporated in the soil, the soil becomes more susceptible to erosion. Thirdly, by removal of the vegetation cover, as results from feeding by the harvester termite and others of similar habits, the ground is exposed in those countries where the violent onset of the rains after a prolonged dry season makes a vegetation cover the only protection against serious erosion.

"The direct relation of the termites' work to denudation" is commented upon briefly by Drummond. This aspect has not received the attention it merits, though Drummond's observations were sound. He refers to the fury of tropical storms blasting the forests and soils and removing both the temporary tunnels built by termites for foraging purposes, as well as eroding away the mounds:—

> "When the earth tubes crumble into dust in the summer season the debris is scattered over the country by the wind, and in this way tends to increase and refresh the soil. During the rains again, it is washed into riverlets and borne away to fertilize

with new alluvium the distant valleys or carried downwards to the ocean . . . . Herodotus with equal poetic and scientific truth describes Egypt as 'the gift of the Nile'. possibly had he lived to-day he might have carried his vision farther back still and referred some of it to the labours of the humble termites in the forest slopes about Victoria Nyanza."

Conclusions

Apart from the more obvious damage done by termites to timberwork, to counteract which work is being done on the repellent action of various chemicals, there are indications that the activities of termites widely distributed in the soil of East Africa, at least in localities under five thousand feet above sea level, are not altogether beneficial. So little is known of the termite fauna, and particularly of the diverse habits of the different species, that detailed discussion of the problem is difficult. Termites are suspected of having a great influence on soil fertility, and through this on the distribution of natural vegetation. The complexity of the problem demands teamwork not only by entomologists specializing in systematics, biology and physiology but by soil chemists and botanists. Teamwork on the study of termites in the field is urgently needed to put this group of insects into proper perspective, especially with regard to their influence on agricultural practices and land utilization generally.

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A WARNING

Eye Trouble Attributable to Photosensitization Following the Use of Phenothiazine in Bovines

By Barabara L. Duthy, Zoologist, Veterinary Research Laboratory, and R. W. E. Lewis, Veterinary Officer, Kenya

(Received for publication on 18th November, 1948)

A type of keratitis affecting bovines, following treatment with phenothiazine, has been studied in calves and reported on fully by New Zealand workers, but so far this condition has not been recorded in Kenya. According to Whitten and Filmer (1947) this keratitis is due to photosensitization, and though it may be severe all animals eventually recover. The vision returns to normal in ten to fourteen days, except in very severe cases with deep ulceration, which recover more slowly and in which a small scar may be left on the eye; this persists for three to four months. These scars, however, appear to have little or no effect on the sight as they are not central in position. Clare (1947) found that phenothiazine sulphoxide, a breakdown product of phenothiazine, was present in the blood and in the aqueous humour of the eye about 24 hours after dosing calves with phenothiazine. Clare, Whitten and Filmer (1947) showed that the phenothiazine sulphoxide in the aqueous humour of the eye was the photosensitizing agent. Calves exposed to direct sunlight 24 to 48 hours after dosing with phenothiazine developed this form of blindness, but they

proved that it could be prevented completely by keeping the animals in shaded or darkened places during this critical period. It was reported by Whitten and Filmer (1947) that calves receiving a good diet suffered less than those on poor grazing. Clare (1947) recorded that phenothiazine sulphoxide is not present in the blood or aqueous humour of the eyes of sheep dosed with ordinary therapeutic amounts of phenothiazine, which explains why sheep do not suffer from this form of keratitis.

During 1948 a farmer in Ruiru procured a number of Zebu Boran heifers from Rumuruti. These animals were in good condition when they arrived, but they rapidly lost condition. They were examined clinically and fæcal examination revealed that the cattle were suffering from strongyle infestation. As there were other Zebu native cows already on the farm which also showed loss of condition, the farmer was advised to dose all the cattle with phenothiazine. A few days after dosing, a number of these animals were found to be affected with severe keratitis. The grazing on the farm, owing to the drought, was very parched and scarce, and the animals were in very poor condition.

Eight heifers were dosed on 16th September, and they all developed eye symptoms in varying degrees of severity, while three developed severe keratitis in both eyes. Seven more were dosed two days later: of these two became blind, and the rest partially blind, lachrymating profusely, and the cornea became cloudy. All these cattle were dosed with from 30 to 60 gr. of phenothiazine according to their size. Animals dosed one morning were noticed to have watery eyes 24 hours later, after which the condition appeared similar to contagious ophthalmia of cattle, which is often seen during the dry weather in Kenya. In all cases both eyes were affected equally. Ten days after dosing all except three animals had recovered; and one week later only one beast was still affected. This animal had deep ulcerations of the cornea which may, however, have been caused by a subsequent injury as the animal was unable to see properly. All cattle subsequently dosed were kept indoors for the first 48 hours after dosing, and this simple precaution sufficed to prevent any further eye troubles following the use of this drug.

Phenothiazine is undoubtedly the best anthelmintic available for all roundworms of cattle, and it is especially efficacious for hookworms (*Bunostomum trigonocepgalum*) of calves. It is obvious, however, that calves being treated with this drug, especially if they are on poor grazing, must as far as possible be kept out of bright sunlight for at least 48 hours after dosing.

Summary

Keratitis in Kenya cattle following dosing with phenothiazine is reported. This may be prevented by the simple expedient of keeping the cattle in the shade for 48 hours after dosing.

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THE USE AND MISUSE OF SHRUBS AND TREES AS FODDER*

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Joint Publication No. 10 of the Imperial Agricultural Bureaux, 1947, under the above title courageously attempts a global picture of the extensive and diversified problem of utilizing shrubs and trees as sources of fodder for stock whilst retaining their maximal soil conservancy values over vast areas of the earth's surface which are subject to markedly different climatic, soil, husbandry and human influences. A short review cannot adequately hope to cover the large volume of information collected in this publication which should be read in the original to appreciate its value and the many angles from which the problem has been investigated and so, no matter how dangerous generalizations may be on such a large and diverse subject, only a very superficial summary will be attempted.

It is a humbling fact to realize that probably more animals feed on shrubs and trees, or on associations in which they play an important part, than on true grass or grass-legume pastures. The general picture over the major portion of these vast areas, particularly in semi-arid climates, is one of gross overstocking with a resultant deterioration in the vegetative cover and a reduction of its power to protect soils adequately against erosion. Whilst a reduction may be effected in the excessive pressure on these vegetational types by improvements in the management of true grassland areas and in fodder production from arable land, these shrub and tree associations must continue as important sources of fodder for some time, at least for low grade animals producing wool, hides, skins and meat, where mere numbers are considered of greater value than quality.

In Africa, two major conflicting factors are possibly more apparent than in any other continent, namely (*a*) natural trees and shrubs over large areas are browsed by, or are lopped or cut as fodder for domestic animals, whilst (*b*) the degree to which these plant associations are utilized for feeding purposes seriously influences their conservancy values. Generally speaking, trees and shrubs should play a secondary role in stock feeding wherever grass is growing, or can be encouraged by suitable management or cultivated on cleared land, because they provide only a limited quantity of dry-season reserve fodder and greater nutritive returns would be secured by conserving surplus wet-season pasture and herbage growth for use at the appropriate time. In the semi-desert scrub and similar vegetational types where grass growth is scanty and nomad economies, based on the browsing of trees and shrubs by camels, goats and other animals, cause considerable and often disastrous damage to the vegetation, the antagonism between the two above factors is apparently insoluble except by reducing and controlling rates of stocking and tree lopping to a minimum in order to allow the vegetation to resist erosion successfully.

At least 75 per cent of the trees and shrubs in Africa are browsed to some extent by domestic and game animals but it is necessary to distinguish between animals as the different classes depend in different degrees on browsing. Cattle prefer and normally thrive best on grass or herbage pastures; sheep also prefer normal pastures, although they may do well on certain types of low browse vegetation, as in the Karoo; goats prefer browse or mixed browse-grass pastures and thrive well upon them. Many classes of game animals live almost entirely on browse plants, whilst others prefer grass. In this connexion the Mpwapwa experiments on the controlled grazing of *Cynodon* pastures, which under the local conditions revert to bush, are stimulating and suggestive. Plots grazed for six years only by cattle became open thickets sufficient for tsetse invasion but with poor grazing and many patches inviting erosion. On the other hand, plots grazed exclusively by goats remained grassland with insufficient bush cover for tsetse flies, in fact the plots developed into good grazing for almost any class of stock.

Before considering representative African territories, it is stressed that preservation of a vegetative cover should be the primary objective as this ensures conservation of the soil. If it is found that browsing can be practised after the basic requirements of conservation have been met, existing browse plants will supple-

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ment grass and contribute to the diet of stock. These plants, in contrast to grass, come into leaf very early and before the first rains and their vegetation retains its nutritive value well into the dry season. Over-grazing of bush or woodland grazing is quickly followed by serious erosion, whilst moderate grazing leads to a gradual replacement of grass by bush until grazing becomes impossible. In areas not too arid for grasses, trees and shrubs, if prevalent, reduce the density and vitality of the grasses competing for soil moisture and nutrients and so bush encroachment in such areas increases the dangers of erosion because the stems and roots of woody plants provide less protection for the soil than grass. The weeding out of woody regeneration in such pastures greatly increases their carrying capacity. In fact, the problem of management is still a subject of controversy and the only use of trees for fodder, on which there is general agreement, is the feeding of pods from leguminous trees.

British Somaliland

In British Somaliland trees and shrubs are a most important source of fodder because grass is scanty and of poor value over most of the country. In some areas and seasons the large numbers of sheep, goats and camels are almost entirely dependent on such browse plants. Trees and bushes are lopped and cut by the herdsmen to provide food for their stock, often to the point of killing the plants, and large areas have become devastated because of over-grazing, tree and bush destruction and erosion. Earlier work has shown remarkable recovery of grass in certain areas not too badly devastated and suggests that some form of deferred grazing, with adequate resting periods, is a promising rehabilitation measure. Unfortunately such schemes have not been widely nor rigorously applied and many areas are now stated to be beyond redemption and are rapidly being converted into sandy deserts.

Sudan

In the Northern Sudan, where rain falls but seldom in decades, an ephemeral growth of grass and herbs springs to life after rain but trees and shrubs provide the main source of fodder. Even in areas where annual rains can be relied upon, grass and herbs provide nutriment for a very short period and the herds of camels, sheep and goats obtain a large part of their food from leaves and pods of trees and shrubs. Herdsmen, in contrast to the British Somaliland nomads, are most careful when shaking down pods not to damage the trees or shrubs. Damage to trees and shrubs by browsing is significant only where the pressure of stock is excessive as when confined to a limited area around water. *Acacia* pods also play an important part in the feeding of stock along the Nile. Even in the acacia/grass savannah region, browse plants and tree pods are important sources of food when the camels and cattle return for the dry season grazing. In the great swampy areas of the Upper Nile, the Nilotic tribes maintain their cattle on grass without relying on browse plants.

Nigeria

Trees and shrubs are much used in Northern Nigeria to supplement grass in the dry season and when crops are ripening and at all seasons by nomadic stock-owners. Lopping and the cutting and bending down of branches are common and legislation has been introduced to prevent further damage in certain areas, especially since uncontrolled slashing and breaking down of branches for fodder greatly increases the destruction due to fire because the straggling broken branches enable the fire to reach the crown of the trees.

Gold Coast

In the northern Gold Coast savannahs, fodder trees play an important part in feeding live stock, though their use will decrease as better methods of grassland management and fodder conservation are evolved. In the dry season certain trees are lopped for fodder but edible shrubs are scarce. In other areas there is no lopping and carrying of branches for fodder and browsing is entirely fortuitous. Browse plants have a place in the densely populated regions, and it is suggested that shrubs might usefully be planted round farms as a fodder "cafeteria".

Kenya

In Kenya uncontrolled shifting cultivation, particularly in regions of low and erratic rainfall, has contributed greatly to vegetational devastation. Over-grazing in the Northern Frontier District and uncontrolled browsing in other parts have led to serious erosion and measures directed towards controlled grazing, reduced stocking and improvements in the management of land and grazings are the basis of conservancy schemes. Goats are regarded as the "archdemons of the soil erosion tragedy" though naturally they are not the only browsing animals. The Northern Frontier District with its low rainfall, its desert grass-bush and

semi-desert vegetation (in which only a sparse growth of grass is found) and its nomadic tribes is the most critical area in Kenya so far as the use and misuse of scrub vegetation is concerned.

Tanganyika

In Tanganyika trees are not used for fodder as much as they would be because of the presence of tsetse flies and trypanosomiasis. Deciduous scrub forms the climax vegetation over large arid and semi-arid areas and here the stock live mainly on green grass until the end of the wet season, then on dried grass and the leaves and pods of trees and shrubs. Dead leaves are picked up during the last half of the dry season. With the advent of the rains, shrubs burst into leaf and the stock feed on these until the grass appears. The browse value of this type of vegetation is high but in any improvement schemes it would be more economic to replace it by grass which will produce a higher yield of fodder without the inherent dangers of thicket.

Uganda

Little use is made of fodder trees and shrubs in Uganda because pastures can be easily established over the major part of the country under adequate rainfall. Even in the driest parts of Karamoja it is believed that good grass can be established and this is the only region where woody plants are used as cattle fodder to any extent.

French West Africa

Fodder trees and shrubs are of considerable value in the thornland, sub-Saharan and desert zones of French West Africa where grass is scanty and of poor feeding value. The halophytic vegetation of saline areas in the desert forms permanent forage for sheep, goats and camels.

South Africa

The South African veld is divided into forest, parkland, grassland and desert scrub and by far the largest part is occupied by the latter which includes the Karoo, but only the areas under desert scrub and grassveld and the fodder plants of the sclerophyllous bush are discussed. The feeding values of South African veld varies enormously with season and rainfall but, whereas grassveld is particularly affected, the fluctuations in scrub veld are much smaller and the vegetation is richer in protein and phosphorous. In the Cape, the grass associations and the "Fynbos" are sharply demarcated, but further north, in the Free State, grassveld slowly merges into Karoo veld with the intermediate zone known as Broken veld. In the latter the percentage of grass varies with rainfall, and where there is sufficient rain to permit grass growth, under-stocking encourages grass but over-stocking eliminates both good grasses and fodder bushes, although these regenerate if the grazing is rested. The percentage of grass increases in rainy years and decreases in droughts. With lower rainfall the Karoo veld is reached where there is very little grass but a very uniform veld composed of a limited number of small drought-resistant bushes, some of which are similar in composition to any good grass. Their digestibility is higher than grass and they can be eaten alone by stock for any length of time but there is no vegetation formation of trees, bushes or shrubs in the Union which provides the sole sustenance of stock. In the grassveld and bushveld, grass provides the bulk of the grazing, the scattered fodder trees are just accessories. In fact, when thornbush and trees spread to the detriment of grassveld, carrying capacity is reduced and there is greater risk of wind and soil erosion.

India

Fodder from trees and shrubs in India is a supplementary fodder except in certain hill districts where there is little or no grass. The country is generally overstocked and, since rains are largely confined to the monsoon period, grass is scarce or non-existent for the greater part of the year. As haymaking and ensilage are little practised, tree fodder assumes great importance in times of grass shortage. It is hoped that the use of tree and shrub fodder will cease with pasture improvement, better conservation of wet-season pasturage and a reduction in stock population. Meanwhile it is necessary to control lopping in the forests and to provide fodder trees where they are scarce in those areas where they can be useful. In reserved forests, grazing and lopping are either forbidden or carefully regulated to certain seasons or approved methods. The following briefly summarizes the position in the different parts of the country:—

Ajmer-Merwara.—Animals feed mainly on tree fodders from waste lands and lopping is widely practised as there is as yet no restriction on this practice.

Baluchistan.—Formerly there was considerable browsing of bushes and shrubs but, like the pasture, this has suffered through recent overstocking and is becoming more scarce

because unrestricted grazing and browsing has ruined many forests and led to erosion. Good pasture could be produced and its proper management and control of grazings are needed more than fodder tree or shrub cultivation.

Bengal.—On the outer Himalayan ranges, where for six months there is practically no grass and very little for the rest of the year, stock are of necessity habitual browsers on plants which would not be touched by plains cattle. The demand for such fodder is great and lopping is freely practised. In the submontane region the demand for tree and shrub fodder is small as grass and paddy straw provide the main feeding. A certain amount of illicit lopping occurs round villages. In the plains tree and shrub fodder is used only in exceptional circumstances. Lopping is prohibited in reserved forests except in the hilly region.

Bihar.—Little use is made of trees and shrubs for fodder and lopping is seldom practised.

Bombay.—Except in the forest areas in times of scarcity where some tree leaves are fed, grass is normally sufficient for live stock needs especially when eked out with crop residues.

Central Provinces and Behar.—These are situated in the drier part of India and the long, dry season makes the use of tree and shrub fodder a serious problem. Trees are lopped for their green foliage, just before the rains break and the grass appears, in private forests and on village lands but is prohibited in reserved forests.

Madras.—The excessive population of scrub cattle of low economic value, especially in dry areas and near reserved forests, has resulted in the complete denudation of grass cover over vast areas except during the short monsoon season. Whilst agriculturalists provide for their utility animals during the hot weather their scrub animals have to depend on what they can find and it is only natural that trees and shrubs should be lopped and cut for their young, green foliage before the grass begins to grow. Lopping is, however, prohibited in the reserved forest areas. Fodder trees and shrubs are therefore used to meet abnormal conditions when grass is insufficient but their use will continue so long as the cattle population remains excessive and until proper pasture management and conservation measures become more popular. In the meantime, the policy is to grow fodder trees in forest plantations in dry districts to create a reserve against seasons of shortage.

Punjab.—There is no shortage of fodder in the irrigated zone, but excessive numbers of cattle are kept in the hills and cultivation is insufficient to provide their fodder requirements whilst, because of over-utilization, forest grazings have deteriorated so that they provide little substance and consequently numerous species are lopped for fodder. Increasing pressure on the land, wasteful feeding methods and the retention of too many unthrifty animals ,have resulted in the rapid destruction of valuable fodder-tree growth.

Sind.—Everywhere rainfall is deficient, but the extensive desert plains are dwindling as irrigational practices are extended. Even so the higher lands, which cannot be irrigated, will remain capable of producing a scanty vegetation of shrubs and stunted trees which can be used for fodder. The pods of *Prosopsis spicigera* and *Acacia arabica* are particularly important, but the removal of leaves from the latter trees has to be restricted to prevent damage to the flowers and consequent loss of pods. In the reserved forest areas sheep, goats and camels are excluded to prevent browsing damage to young trees until the latter are above their reach. All animals are then allowed to graze these areas. A promising technique for developing poor lands, not reached by the floods, is to plant spaced lines of trees and water by irrigation. The intervening spaces are cropped until the trees are too big to make cropping profitable. The area is then put down to grass until the trees are large enough to fell for fuel when the procedure is repeated.

United Provinces.—There is abundant grass in the four-month wet season, but growth ceases during the cold weather and by the time the hot season commences the plains are practically bereft of grass. This, together with the traditional failure to store fodder, forces cattle to wander far and wide for sustenance. For eight months live stock depend on diminishing supplies of grasses and crop residues, and leaf fodder forms an important food, especially in the hills where, without it, animal husbandry would be impossible. Whilst unrestricted lopping occurs in the cold weather in most private forests and scrub jungles a strict control is imposed in the reserved forests and only limited numbers of animals are admitted to certain areas. Periodic closure is enforced to allow trees to recover.

CEYLON

In Ceylon the deliberate use of tree fodder is rare but cattle feed on a number of species to supplement their scanty grazings.

MEDITERRANEAN LANDS

Much of the Mediterranean littoral exhibits the tragic consequences of deforestation and subsequent denudation of the maquis sub-climax cover as a result of burning, fuel cutting and over-grazing. Free range grazing has contributed largely to this destruction and the goat is the worst offender. Quotations from Lowdermilk indicate that nomadic Arabs are outstanding as destroyers of vegetation and that, in view of the deserts created by them and their goats, they should be referred to as "fathers of the desert" rather than as traditionally the "sons of the desert". All degrees of damage can be found from the completely protected forests of Cyprus to the barren hills around Jerusalem. In favourable environments, exclusion of animals immediately allows regeneration but, over vast areas, this process would take a long time if it could happen at all. The pressure on critical areas can only be relieved by the provision of fodder from cultivated forage crops and only too often the fertility of the cultivable land has been reduced below the required level by centuries of mismanagement and erosion. The problem, in fact, appears insoluble on the human or sociological side and there is every prospect of a continuous decline in the capacity of the land to produce whilst there will be a tendency to increase the human and stock populations.

Corsica.—The greater part of this island is unsuitable for cultivation and the poor mountain pastures are grazed by goats, mountain sheep and mules. These grazings merge into the maquis, which is also browsed by goats.

Balkans and Dodecanese.—Suffer from uncontrolled grazing of a very damaging type.

Cyprus.—Over-grazing, burning and fuel cutting has reduced many areas to an advanced state of erosion and until recently, in spite of the goat laws (whereby villages may ballot to prohibit the free ranging of goats), the Forest Department has been much hindered by the destruction of trees by browsing. With the steady increase in balloted villages and a progressive agricultural policy an increasing number of sheep and goats are being confined to a decreasing acreage of land. Closure of some of the worst eroded lands would make the fodder situation even more serious and there appears to be no alternative but to prohibit free ranging of stock and change the animal husbandry to the stall feeding of fewer but better animals.

Syria.—Depends on agriculture and stock raising, but the destruction of old irrigational works by Mongol and Arab raiders has reduced the cultivable area and depopulated large areas. There is a seasonal migration of stock as the flocks of sheep and goats follow the so-called pasture from region to region. Browsing is common on the mountains

Palestine, Transjordan and Iraq.—All suffer from uncontrolled grazing by Bedouin herds. The sparse natural shrub vegetation over large areas is never allowed to recover and progress ecologically to a level at which it might begin to protect the soil. In Iraq attempts have been made to convert the nomads into cultivators, but it is possible that improvements in stock breeding (particularly of sheep) would be a more simple means of increasing the country's wealth. Stock breeding is restricted by the irregularity of grazings and the inadequacy of fodder supplies. Sheep and goats predominate and, together with cattle and camels, are migrated seasonally to follow the vegetation in the steppes and deserts. The former carry a scattered perennial community of low growing shrubs which persist through the dry season and the latter only an ephemeral cover of herbaceous shrubs in the spring which disappears later in the year.

AUSTRALIA

Australia has a large interior region of very low rainfall and the vast desert steppe in the centre merges into scattered acacia, saltbush and mallee and this again merges into the denser vegetation as the better rainfall coastal hinterlands are reached. In this vast area edible trees and shrubs are the most important source of forage, particularly in periods of drought, whilst the ephemeral ground flora is of great value after sporadic rains.

Queensland.—In areas of unreliable rainfall trees and shrubs are of great importance in the grazing economy, for it is not uncommon for a summer to pass without effective rain.

When this happens grass, which normally furnishes the bulk of the forage, is insufficient and the stock supplement their grazings from tree fodder. Overstocking of natural grassland often allows low shrubs to replace the grass and these provide valuable fodder. The graminaceous pastures in areas of uncertain rainfall are inferior, to those in which shrub

species are dominant, for providing a *continuous* supply of fodder for sheep. The summer rains produce a quick growth of grass which rapidly lignify and drop in feeding value. Subsequent rain reaches the mature grass and tree fodder then provides a valuable source of proteins and minerals. It is for providing supplementary forage during droughts that the edible trees and shrubs are most valuable. As the forage (apart from windfalls) is out of reach of the stock, scrub cutting is practised which may mean felling or burning down the complete tree, cutting off the top or lopping the branches according to the type of tree. In the more arid country lopping is regarded as most desirable since this preserves the life of the tree, but the methods are used in a haphazard manner and there is often a lack of any policy for conserving this valuable fodder source.

New South Wales.—In areas of moderate or good rainfall fodder trees and shrubs are of little value in the pastoral economy because grasses and other herbage form the main food but, in areas of low rainfall, they are of considerable value. The latter areas support hardy perennial shrubs or trees and a large variety of annual herbs, but it is the former which provide the main supply of reserve fodder, and it is only through them that pastoral pursuits are possible. In areas subject to heavy stocking, edible plants are eaten out by stock and rabbits and the loss of cover leads to erosion, whilst it is common to find very little development of seedlings and young growth of most edible shrubs and trees. In dry areas the problem of regeneration is best solved by excluding stock and rabbits when a striking recovery of existing and a great increase in the numbers and varieties of plants is observed. Management should ensure resting periods to permit natural regeneration or the establishment of sown or planted seedlings. Scrub cutting should not be delayed until the animals have become weak because scrub feed which keep healthy stock in fair condition is of much less value to poor and weak animals.

Victoria.—Scrub grazing is not of major importance, but is more of a temporary expedient when more desirable fodders are scarce and is almost wholly confined to the Mallee District where, in times of drought, it is the practice to utilize uncleared areas of Mallee (thick stunted scrub with eucalyptus predominating) as emergency browsing. The district flora had deteriorated far more under close grazing by sheep which concentrate near water holes than under cattle which can roam farther afield and do not bite so closely into young shoots. Soil conservation and the reclamation of marginal lands is a major problem as the derelict marginal land is a menace and a harbour for vermin. Graziers on short-term leases are overgrazing abandoned blocks and pay little attention to their maintenance or vermin control until soil erosion renders them unfit for further grazing. They are then abandoned and become breeding grounds for vermin and the nuclei of further erosion which endangers neighbouring blocks.

South Australia.—Shrub steppe is the only area in which fodder trees and shrubs are important, provides reserves of fodder in the long droughts characteristic of this region and supplement the more palatable grass and herbage which grows in the rare periods of liberal rain. Droughts may last for over a year and permanent stocking is only possible because of these drought-resistant fodder trees and shrubs. Nevertheless, the protective value of these plants is more important than their feeding value—a fact lost sight of in the exploitation of the land for pastoral purposes and, in less than a century, 75–90 per cent of the shrub cover has been destroyed very largely by overgrazing. It is essential that further decline is prevented because complete destruction of the protective vegetation renders natural regeneration of the perennial salt—and bluebushes very slow whilst the artificial seeding of denuded surfaces is unsuccessful.

West Australia.—The value of "top feed" plants depends on the value of the herbaceous vegetation; where the latter is rich and plentiful top-feed plants are unimportant nutritionally but provide roughage. Where the herbaceous feed is scarce or becomes so periodically top-feed plants are important and in the Eremean Province are considered of permanent value since they provide the basis of forage over large areas.

New Zealand

In New Zealand the vegetation has developed unexposed to attacks from grazing and browsing animals and is naturally ill-equipped to withstand their onslaught. Animals have, in fact, done considerable damage by eating down and eating out the native vegetation. Studies on the ecology of the present fauna are badly needed and on the proper utilization of indigenous shrubs and trees as supplementary fodders.

U.S.S.R.

In U.S.R.R. deserts, semi-bushy shrubs form the background of the flora and perennial graminaceous plants are either absent or make an ephemeral appearance. The semi-deserts form the transition between the deserts and the steppes and the flora is a complex mixture of the two types. The average yield on all types of pastures is low and haylands occupy only five per cent of the desert and semi-deserts whilst the seasonal distribution of fodder reserves is very uneven, being highest in spring, lowest in the summer, increasing in the autumn and inconsiderable in winter when much of the area is under snow.

Animal husbandry in these regions has always been nomadic or semi-nomadic and is determined by the disproportion between fodder resources from pastures and those held in reserve for stabling the animals. Sheep are kept in the largest numbers and, together with camels, are better adapted than most animals for utilizing *Artemesia* and *Salsola* pastures. Semi-desert vegetation dries up to a less extent in summer than that in the desert so that from April to September the animals are driven into the semi-deserts and mountains and from October to March back to the deserts. In 1929–30, 20 per cent of the U.S.S.R. stock population was kept in these two areas but the animals are small and of low productivity, and the problem is not only to increase numbers of economically important animals but to improve their quality.

The grazing land should be earmarked for each animal species so as to provide an uninterrupted supply of good fodder throughout the grazing period. Cattle prefer plants with soft leaves and stems and consume only small quantities of aromatic or salt-containing plants. Sheep and goats prefer soft fodders but utilize also the young leaves and stems of many bitter and aromatic plants and avoid damp pastures. Horses thrive on xerophytic grasses but can satisfactorily graze nearly all pastures suitable for sheep and cattle. Camels do not utilize grasses and will consume more prickly, bitter, aromatic or salt-containing plants than any other animals. It is more difficult to determine the best time for utilizing different pastures because, although most plants are more nutritious and palatable when young, many desert plants are only eaten in their later stages when their bitterness, objectionable odour or salt-content has been reduced. Owing to climatic variations in deserts and semi-deserts it is difficult to determine the optimal times for grazing, yet success in animal husbandry and in improving productivity is often dependent on the selection of suitable types of pastures for each species and the choice of the best grazing period as well.

Pastures can only be used rationally when animals are paddocked and the grazing periods strictly rotated. Aftermath will not grow on all desert and semi-desert pastures and its autumn growth will be slight, consequently accumulation of nutrient reserves and self-seeding will proceed on all sections normally without any special need for rest periods. Various animal species consume different plant mixtures and the productivity of mixed pastures is greatly increased by grazing, first with one kind of animal and then by other types.

The area of haylands in the desert and semi-desert regions could easily be doubled and so help stabilize the fodder situation in those areas. Cutting for hay is spread out over 3–4 months and greater attention should be paid to cutting the different pasture types at their optimum stage of maturity and to allowing the cutting, collecting and stacking to proceed uninterruptedly within the shortest possible time. The necessity and feasibility of creating fodder reserves in the desert and semi-desert has been proved and the production of artificial haylands and pastures will be required. Even though yields will be low they will exceed in bulk and nutriment the forage growing at present. Planned increases in animal populations and the improvement of their quality will require considerable areas under fodder crops which will include shrubs of greater drought resistance, salt tolerance and nutritive value than grasses.

U.S.A.

It is very difficult to summarize the diversified conditions of U.S.A., but grasses form the main forage on nearly all forest and other ranges in the West and management must be based on the proper use of grasses. They are generally better control agents for erosion, but the use of mixed vegetation of these types for grazing and conservation is not incompatible. Ranges in a deteriorated condition must be restored by management or re-seeding before adequate soil protection can be achieved. In the Western desert areas, where rainfall will only support sparse woody shrubs, a complete ground cover is neither possible nor necessary for erosion control.

Forest Grazings.—Grazings should be arranged so that sustained forage and live stock

production will be obtained and regeneration of the forest will be permitted. The aim is to harmonize grazing with the primary objectives, i.e. production of forest products and protection of watersheds, and this involves a determination of which class of stock are best suited to the range and what should be the grazing periods, intensity of stocking and management.

Most pine forests of the West and of the South and South-eastern Coastal Plains are sufficiently open to allow an under story of grass and shrubs which can be used advantageously for grazing provided its management allows timber regeneration also. In the denser coniferous forests in the West and the Piedmont, grazing can be permitted but the grazing value is low due to the thinner under story. The open juniper forests of the Western ranges and the woodland-chaparral of California afford considerable grazing. The herbaceous plants and some shrubs are palatable and nutritious. In the higher mountains the ranges are used chiefly in summer, in the foothills in the spring and autumn, whilst on the plateaux of moderate altitude grasses cure well on the stalk and furnish good grazing throughout the year. The Californian woodland-chaparral, which is characterized by annual grasses and herbs and by perennial shrubs is grazed primarily in winter and is considered rather good spring fattening range. In this latter range type, cattle gain more weight on moderately grazed than on heavily grazed ranges. The grasses in the open pine forests are palatable and nutritious during spring and early summer, but lose their value in the autumn and winter. Grazing in this range type requires mineral supplements all the year and other supplements in the autumn and winter. The ericaceous shrubs found there are generally of low feeding value.

Range management in the cut-over forests in the coastal plain of Georgia must be built around perennial grasses as they form most of the cover and grazings. Few shrubs in these cut-over areas furnish much grazing and supplement the grasses. They are browsed mainly in the critical winter season when grasses and other herbs are scarce but not when grasses are plentiful. In fact, they rarely provide more than from a trace to 25 per cent of the grazings and, when these shrubs increase in abundance, the grazing capacity decreases.

Natural regeneration of coniferous forest is not palatable to live stock, but serious retardation of regeneration may occur if the range is heavily over-grazed.

Goats have been used extensively to clear brush in the Ozark region of Missouri and the Pacific North-west and other areas. Generally, this requires heavy over-grazing and the animals' conditions suffer. Many Angora goats are successfully grazed on brush ranges or are combined with other stock to keep brush in control without over-grazing the land and allowing the brush to be maintained in productivity.

In the South and East a minority of farmers favour burning and cause serious risks of forest fires. Prescribed burning in long-leaf pine forests may be used to provide fresh and easily accessible forage but only when fitted to local conditions. Annual burning reduces timber growth and is less suitable for forage than periodic burnings. No burning is permitted in the southern coastal ranges outside the long-leaf pine forests. Experiments in Mississippi showed that annual burning of long-leaf pine lands prevented the seedlings growing out of the grass stage but maintained a better forage than the exclusion of fire. Non-burning allowed pine litter and dead grass to smother fresh grass growth and lower live weight gains were obtained. A rotational system of controlled burning would be better than either fire exclusion or annual burnings. Cattle have a real value in reducing fire hazards by trampling and eating forage plants which contribute to the inflammable under story.

Some hardwood forest trees are rather palatable to stock and regeneration can be prevented under what might normally be termed moderate grazing. In the hardwood forests of the central portion of the United States grazing should be light or not at all because of scarcity of palatable herbaceous plants. In the eastern mountains live stock are excluded and game are controlled in order to maintain a good forest cover. Sheep, goats and pigs are blamed by southern foresters for damaging pine production. In the hardwood forests, cattle can be allowed to graze until the available herbs and grasses no longer satisfy their needs and they begin to browse the trees. Cattle grazing should not be permitted in a forest where no broad-leaved herbs or grasses are available at any season. As timber stands grows on cut-over lands they decrease the forage available and, unless this is allowed for, some tree browsing occurs. In the corn belt of the mid-west, it is generally advisable to eliminate grazing from the forest lands to assure maximum timber production.

Controlling Shrubs on Grassland or Other Ranges.—Many western ranges have deterior-

ated through abuse, drought or fire from fairly open grazing land or savannah types to a heavy cover of shrubs with a minimum of grasses. Many of these lands are eroding and suffering further reduction in productivity. Attempts are being made to convert these brush lands into productive grasslands and two successful efforts have been made in the dense big sagebush areas of the Intermountain region and the mesquite-burrowed areas of the South-west. Big sagebush does not sprout from its roots and can therefore be removed readily by controlled burning. Where there is a good cover of perennial grasses, protection from grazing for a year or two allows rehabilitation and increased carrying capacity, but re-seeding is necessary to establish good grass cover where there is only a thin stand of grass under the dense sagebush. Ploughing with discs or harrow ploughs successfully eradicates big sagebush and seeding can be carried out at the same time. The invasion of grassland by mesquites can also be successfully combated by poisoning with arsenite. On the other hand, it is difficult to control shrubby species which sprout. Several millions of acres of California are of practically no grazing value because of Chaparral, which is represented by two distinct growth forms—a non-sprouting and a sprouting. The former can be dealt with by burning or cutting but the latter, when cut or burnt, sends up vigorous shoots and are most difficult to eradicate.

Grubbing and burning, followed by spraying and mowing, have proved effective in removing invading burroweed from Arizona and snake weed from New Mexico and Arizona grasslands. Grubbing, dragging with railroad iron and scraping with a road grader have been used to eradicate prickly pear and other cacti in many States.

Browse as Forage.—Shrubs augment the grazing value of almost all ranges and may occupy from 10–80 per cent of the plant cover on forest ranges. Generally they are of low palatability and provide only 2–30 per cent of the nutrients obtained from grass and herbs by cattle and sheep. In the case of goats, these browse plants can provide from 50–75 per cent of the total forage in autumn and winter. Even in grasslands, scattered browse plants provide some fodder and are of value in maintaining protein intake in autumn and winter. In the true shrub types of vegetation in the West, particularly in the Southern desert and salt-desert shrub, browse often furnishes a higher proportion of the forage of cattle and sheep than in the forest under story or on grasslands. The grazing capacity and proper utilization in many of these shrub types is determined by the extent to which grasses can and should be grazed and maintain their full productivity or re-establish if deteriorated.

CANADA

Although grasses and other herbaceous plants form the bulk of the grazing in Western Canada, trees and shrubs are important sources of fodder in some areas. Few shrubs and no trees are of forage importance in the open prairies of Saskatchewan, Manitoba and Alberta but, in the Aspen Grove zone of these Provinces, the Rocky Mountain foothills of Alberta and the forest ranges in the interior of British Columbia, trees and shrubs contribute a large portion of the total forage.

Attention has been paid largely to grassland areas of Western Canada and knowledge of forage trees and shrubs is incomplete. Many of the forests of Western Canada, including some grazing zones, are dominated by relatively unpalatable conifers which are not browsed, although Douglas fir is eaten in the coastal region. The principal forage tree family is the Salicaceæ, most of which are palatable, although the broad-leaved members are generally more palatable than narrow-leaved species. They are grazed when herbaceous forage dries up and quickly send up new shoots to replace those eaten off. The willows dominate newly burnt areas and may supply much forage. The only poplar of major forage value is the Aspen which is eaten by all classes of live stock. The young parts are preferred and heavy grazing may interfere with its reproduction. Aspen forests are more open than coniferous ones and the ground cover of herbaceous shrubs and herbs is more luxurious. Hence Aspen is of grazing value not only for itself but because of its associated vegetation.

Palatable shrubs are more widely distributed and of greater aggregated value than trees in Western Canada. Of the Chenopodiaceæ, winterfat and salt sage are palatable and nutritious and may form 10 per cent of total forage on some ranges in the Prairie Provinces. They decrease with heavy grazing but are of value for fall and winter feeding. A number of species of *Rosa, Spiræa, Dasiphora, Rubus, Amelanchier* and *Prunus* are eaten but are not of great feeding value except the Saskatoon bush. Silverberry, low buffalo-berry, western snowberry and lowbush cranberry are eaten to some extent; involucrate honeysuckle and

mountain snowberry, mountain and red huckleberries are fairly palatable, whilst the Rocky Mountain and vine maples, shrubby red osier dogwood, rabbitbush and hoary sage bush are eaten to a considerable extent.

Aspen poplar and broad-leaved willows are richer in desirable constituents than the principal herbaceous plants available at the same time, the phosphate content being of particular value since it is rather deficient in the later stages of grass growth. The shrubs are also rich in nutrients and tend to maintain these higher levels to a later stage than grasses. Cured forage containing a fair percentage of browse is more palatable and nutritious than cured grasses alone and a pasture containing some browse plants is of a greater value than one occupied by grass alone. In Western Canada during critical shortages of herbaceous feed in the pasture lands, trees and shrubs other than those normally considered palatable are browsed. Trees and tall shrubs are also of value in unsheltered range in protecting live stock from winter winds and summer heat and flies.

The Composition and Digestibility of Fodder Shrubs and Trees

The propagation of edible shrubs and trees may not be a considerable long-term policy for providing fodder in regions of low or uncertain rainfall, but they are, nevertheless, of considerable value in tiding stock over periods of fodder scarcity. Some 894 analyses are given of the composition of the edible parts of over 500 trees and shrubs and in general it appears that the clearly defined seasonal changes in protein and phosphorus found in grasses are not so evident in the foliage of trees and shrubs. In seasons of drought when grass is scarce, and what is available is at its lowest level of protein and phosphorus, tree and shrub foliage continues to be moderately well supplied with these important nutrients. Pods of leguminous trees in these areas usually ripen and provide additional supplies of these constituents when grasses are at their lowest seasonal levels.

The value of these emergency fodders depends on their digestibility and 110 digestible nutrient contents are given for some 78 tree and shrub fodders. It is not possible, as for grasses, to work from the available figures the relationship between crude fibre content and digestible organic matter for tree and shrub foliage.

From the information available, the pods and leaves of edible trees and shrubs are, with the exception of certain low protein *Opuntia* spp., equivalent to British meadow hay as sources of digestible protein and energy on a dry matter basis. They are generally superior to local grasses or hay, grazed or harvested after periods of drought in areas of low or uncertain rainfall. They cannot, however, compete with cultivated fodders in dry matter yield over a period of years when the management is designed to produce sustained yields and conserve soil and water.

CROP PROTECTION

This year on the 21st to 28th July the Second International Congress of Crop Protection will take place in London under the presidency of the Right Hon. The Viscount Bledisloe, P.C., G.C.M.G., K.B.E., F.S.A.

The Congress will be organized in six sections for the reading of papers and discussions. The sections are Insecticides, Fungicides, Plant Growth Regulators, Toxicology of Crop Protection Substances, Methods of Application, and Analytical Methods and Standardization, each section having its own chairman and secretary.

During the meetings there will be congress lectures and visits to research stations and laboratories.

Those interested who will be in the United Kingdom at that time can join the Congress on payment of a fee of £2; application should be made to the Hon. Organizer, Mr. Francis J. Griffin, 56 Victoria Street, London, S.W.1.

FIG. 1.—Carpenter Bee and its Meloid enemy (x $\frac{2}{3}$).

FIG. 2.—Blackened borings of Ambrosia beetles (x $\frac{1}{2}$).

FIG. 3.—*Xestobium Lyctus Platypus* (x 7).

FIG. 4.—White tails of frass issuing from fresh Ambrosia borings (*Platypus*) (x $\frac{1}{2}$).

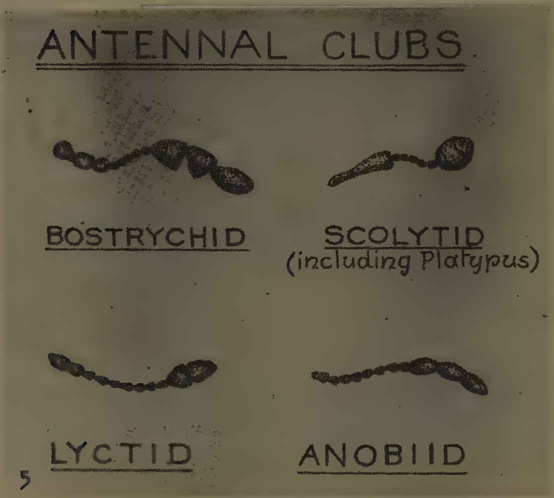

FIG. 5.—

FIG. 6.—A typical *Bostrychid* (x 6).

FIG. 7.—*Scolytid* gallery patterns (x ½).

FIG. 8.—A typical *Scolytid* (x 8).

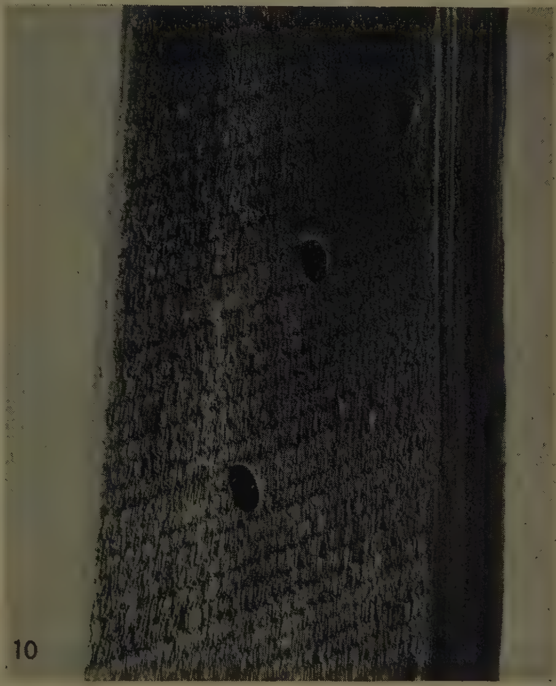

FIG. 9.—Resin-flow due to attack by *Scolytid*.

FIG. 11.—A typical Longhorn Borer—family *Cerambycidæ* (x 2).

FIG. 10.—*Cerambycid* borings—oval holes.

FIG. 12.—Long-horn tunnels under bark, showing commencement where egg was laid (*top right*) and deep boring (*bottom left*).

FIG. 13.—Long-horn emerged from pupal chamber.

FIG. 15.—Long-horn attack around pruning scar of cypress.

FIG. 14.—Long-horn larva and pupa (x 2).

FIG. 16.—A typical *Buprestid* beetle and its larva (x 2).

FIRST PRINCIPLES IN THE PROTECTION OF TIMBER AGAINST INSECTS

By F. G. G. Peake, Forest Entomologist, Kenya Colony

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Although generally speaking it can be said that certain families of insects do certain types of damage, the rules are not hard and fast and, if one were to work on the generalities and write a simple account thereon the exceptions would soon become apparent. This is very unfortunate because it does not need an entomologist to recognize the quite different-looking types of insect which infest timber (anyone can do that after a little instruction) and it would be very simple if diagnosis and treatment could there and then be fixed.

The writer has therefore decided to classify not the insects but the timber diseases, a very sound basis on which to start, because a piece of timber is so often found riddled with holes or reduced to powder without the slightest trace of the insect itself. Furthermore, treatment can frequently be decided upon on seeing the damage without the insect, whereas in many cases it would be unwise to draw conclusions on seeing the insect alone. Following this principle, infested timber may be classified according to its visible characteristics.

Fortunately, the system is much simplified in East Africa through the absence so far as is known of any serious damage by Lepidopterous or Hymenopterous borers with the exception of the Carpenter Bees. This means that we are concerned primarily with beetles and their grubs. A key to the classification of infested timber appears below*:—

Round Hole Boring Insects

This section deals only with those insects making *round holes* in timber; perfectly round holes, not even slightly misshapen. In this connexion it is necessary to remember that a round hole cut obliquely by the saw becomes an ellipse, while an oval hole cut on the slant may look almost round. As indicated in the above table, the borer-holes in this category may contain borer-dust, but never in a hard compacted form. It may fill the tunnel completely, as with some Bostrychids, but tapping will bring some of it out in a cloud.

I—Very Large, Perfectly Round Holes

These quite artificial-looking borings, going straight in, sometimes to a depth of eight or ten inches, vary from ½ in. to ¾ in. in diameter or even slightly more. They are the work of Carpenter Bees (Xylocopidæ) and are made in dead, dry timber. One commonly sees a number of shallow trial holes as well as the deep ones and, whether shallow or deep, they all have the apearance of being clean and empty. The insects themselves look like enormous bumble-bees, have a wing-span up to 2¼ in. and a round body, steely-blue or banded with orange. They are rather difficult insects to deal with, as they do not eat the timber and cannot be poisoned thereby. They feed off flowers and use the timber merely as a shelter for their eggs which hatch inside the tunnel, the young grubs feeding on a ball of "bee-bread" which has been provided for them. These growing grubs could be killed by a fumigant such as Paradichlorobenzene or even Flit or other pyrethrum preparations, the opening being closed with clay afterwards, but this would be a laborious process and, in any case, the damage has already been done. Neither is there any reason to suppose that the newly-emerged insect would, if allowed to

* Wood with round holes, wood dust if present in tunnels can be shaken out:—
 Large perfectly round holes: Carpenter Bees, Xylocopidæ.
 Small perfectly round holes:—
  Holes black stained: Ambrosia Beetles, *Platypus*.
  Holes not black stained:—
   Wood reduced eventually to powder; tunnels coalescing—
    Beetles with three-club antenna: Bostrychids, Bostrychidæ.
    Beetles with two-club antenna: True Powder-post Beetles, Lyctidæ.
   Wood not altogether reduced to powder; tunnels separated by solid wood—
    Beetles with three-club antenna: Furniture Beetles, Anobiidæ.
    Beetles with one-club antenna: Bark-beetles, Scolytidæ.
Wood with oval holes, wood dust in tunnels compacted: Longhorn Beetles, Cerambycidæ and Jewel Beetles, Buprestidæ.
Wood with irregular cavities, wood dust in the form of small pellets: White Ants, Isoptera.

escape, attack the same timber again or even stay around the same area.

I have noticed firstly that the bees prefer podo and secondly that they seem confined to outside woodwork. Cedar fence-posts are also attacked, whether of sapwood or heartwood. Fortunately the bees have a formidable enemy, namely a large red beetle of the Meloidæ, with scythe-like jaws. It may often be found dead on the ground under the eaves of podo buildings (Fig. 1).

II—Small Perfectly Round Holes

In this category are circular holes rarely more than ⅛ in. in diameter (very occasionally up to ¼ in.) and ranging down in size to the merest pin-prick. Such holes offer quite a number of possibilities, but we can again simplify matters by noticing whether they are stained black inside or not. This is not difficult to see as the blackness generally permeates the wood immediately around so that it can be seen even in cross-section (Fig. 2).

(1) *Holes black as if made with a red-hot needle.*—

These are the tunnels of Ambrosia Beetles and, in East Africa, almost invariably the work of *Platypus*, a genus of beetles with a large number of species. *Platypus* is a slender and sometimes very minute beetle and, although it may reach a length of ¼ in., its narrow parallel-sided body gives it a very small bulk and accounts for the fact that these blackened Ambrosia tunnels are never very large, 1/20 in. being an average size. The beetle has a somewhat curious appearance in that each leg terminates with a long and slender tarsus which, in the front pair, is directed backwards instead of forwards (Fig. 3). This, together with the single clubbed antenna and the fact that head, thorax and abdomen are all about the same width, gives the beetle a characteristic appearance. But the work of *Platypus* in the forest is even more easily recognizable to the forester than its minute personality. Freshly felled logs and occasionally standing trees may be seen to have white dust pouring out from pin-pricks in the bark or even white vermicelli-like threads (Fig. 4). These threads are really coherent strings of borer dust or, more correctly, borer shreds, for when looked at through a lens they are seen to be made up of interlocking splinters. Sometimes this excavated wood is pushed out as minute, rather waxy-looking tubes. The boring is the combined work of the male and female beetles, the female doing the hard work of excavation and the male merely pushing out the chips. In this tunnel, which goes straight into the log for eight or ten inches, are laid the eggs, and a fungus is sown to provide the young grubs with food, for *Platypus* beetles are (almost always) of the Ambrosia type and do not eat the wood itself. In spite of all this housework the female lays a hundred or even two hundred eggs, and often frequently to no purpose if the log is speedily removed and stored under dry conditions. Only when the log remains slightly damp does her fungus-garden flourish and her family prosper. This means that, whether in the forest or in the mills, the answer to *Platypus* infestation is keep your timber dry.

(2) *Holes not black-stained.*—

In this section we have most of the worst timber borers, namely those that live and can multiply under the dry conditions of seasoned wood in a timberyard or even in building timbers and furniture. Bearing in mind that we are still dealing only with small round holes, we may now make a subdivision according to the general condition of the wood when heavily attacked, that is, whether the holes lose themselves in a powdery mass or whether they tend to leave solid timber between them. Very naturally this is not always an easy point to decide when the attack is just beginning, but in this case one should find grubs and beetles in the wood, and these will give the correct clue.

(*a*) *Holes lose themselves in a powdery mass.*—This state of affairs is due to beetles of the families Lyctidæ and Bostrychidæ. Members of both these families are commonly known as "Powder-post Beetles", although strictly the name is applied only to *Lyctus*.

Lyctus is the true Powder-post Beetle one hears so much about in the temperate climes, the reason being that ring-porous timber with large spring vessels is grown in those latitudes (e.g. oak, ash). It is a very notable feature that the female beetle inserts her eggs actually into the cut ends of the wood vessels. The egg of *Lyctus* having a definite size, this means that only those timbers are attacked which, in the first place, are broad-leaved trees and which, in the second place, have vessels of a sufficiently large calibre. It therefore follows that all coniferous timbers are immune from attack and that large vesseled wood such as oak, ash, and for that matter *Mvule, Chlorophora*

excelsa, are liable to infestation. It appears to make little difference whether the timber is recently felled or whether it has been well seasoned, but one usually associates *Lyctus* with household commodities of seasoned wood. In many timbers the sapwood is the only part attacked. The tunnels are irregular, deep and so close together that the wood is soon reduced to powder. It is quite usual for small articles, axe-handles and so on, to be attacked.

The insects themselves are small, brown beetles, some $\frac{3}{16}$ in. long, narrow, parallel-sided like *Platypus*, but *flattened* rather than cylindrical. The head is (like *Platypus*) not hooded by the prothorax, so that it is plainly visible from above, the eyes projecting prominently on either side (Fig. 3). Another characteristic which distinguishes this beetle from *Platypus* is the antenna, which terminates in a *double* instead of single-headed club. The larva, a curved, wrinkled grub, has very minute thoracic legs.

The best method of exterminating *Lyctus* in infested timber is by wet or dry heat. All stages of the insect succumb very readily to heat and at comparatively low temperatures. Where kiln-seasoning is not possible, the timber may be dipped in a $1\frac{1}{2}$ per cent solution of boric acid in hot water, allowing the timber to cool in the solution. If the heat (just below boiling) has had time to penetrate the wood, the beetles and grubs will be killed, while the superficial penetration of the solution will prevent later infestation. Copper or galvanized tanks should be used for this process, not iron, and even iron nails in wooden butts may cause black staining.

The Bostrychids (several genera of the family Bostrychidæ) are all too common, very destructive in sawn and converted timber, and particularly notable for their variation in size. Unlike *Platypus* and *Lyctus*, which are always minute beetles, Bostrychids may make holes anything from pin-hole size up to $\frac{1}{4}$ in. There are numerous species, as one would expect with such variation in size of hole, and they are typically cylindrical, dark-coloured beetles with one or both ends bluntly rounded or cut off almost square (Fig. 6). Jags and horns at either end of the body are quite common. The sizes which approximate to *Platypus* and *Lyctus* may, with a powerful hand lens, be distinguished from either of these two by the form of the club which terminates the antenna. *Platypus* has a single round club, *Lyctus* a two-jointed club, and all Bostrychids have a three-jointed club (Fig. 5).

Of the smaller Bostrychids, a familiar one to most people is the minute Bamboo Borer (*Dinoderus* sp.). Bamboo being such a widely-used material one would expect the beetle to be found everywhere. On the contrary, its presence seems to be quite sporadic. Enclosures fenced with bamboo, military quarters with indoor structures of bamboo, and so on, have often shown no trace of infestation whatsoever in either new or old material over a large area searched. On the other hand, an occasional hut may be found far from other habitations with the roof rapidly collapsing. This would lead us to expect that the insect originated in occasional culms brought from the extraction area, a theory which may yet prove to be true, but up to the present we have never found the beetle in bamboo forest. However this may be, it does not appear worthwhile to treat all bamboo systematically prior to marketing.

In other parts of the world (notably in India, for the protection of tent-poles) treatment with various preservatives has been tried, using both water-soluble salts and other fluids such as creosote. Holes have to be bored between each node to allow entry of the liquid used. Where split bamboo is used the treatment is, of course, much simpler. In addition to this, many experiments have been made working on the world-wide and time-honoured principle that bamboo felled at certain seasons is more immune from beetle attack than that felled at others. Impregnation with chemicals dissolved in paraffin is expensive and water-soluble salts (except for use in seasoned bamboo) are not to be recommended on account of the splitting that occurs on subsequent drying. In all, it appears that soaking split bamboos in water for two months or more is the best method, a treatment discovered from the fact that bamboos previously used for rafts were found to be immune. Although it has already been said that the treatment of all bamboo is probably not warranted, the principles of bamboo preservation are discussed here for the following reason. We have discovered in Kenya the Bamboo Beetle taking to eating ply-wood in the factory, split bamboos having been used to separate the stacked ply-wood sheets. In this case the ply was of *Mwafu**, a light and large dimensioned timber from Jinja. It would be

* Muwafu, Luganda, *Canarium schweinfurthii* Engl.— Ed.

worthwhile treating the bamboo used for such a purpose, the treatment being a dip of 1½ per cent boric acid in hot water just under boiling point.

(*b*) *Holes still separated by solid wood, not lost in a powdery mass.*—Only two families concern us here, the *Bark Borers* (Scolytidæ) and the *Furniture Borers* (Anobiidæ).

The *Bark Borers* rarely tunnel more deeply than the outermost layer of wood, but we have one, mentioned later, which I have found riddling a 20-year old podo door. The Scolytids of more usual habit are also found in East Africa and their rather pretty gallery patterns (Fig. 7) may be found under the bark of dead and dying trees. In some instances such Bark Beetles may be a menace in the damage they do to living trees, but, so far, we have found only those that attack trees already suppressed and dying (Fig. 9 shows typical resin flow). One small Scolytid, although quite harmless as a grub boring under bark of dying cedars, was found in its adult flying stage to be browsing off the young growing shoots of cedar and cypress. It bores a little cavity in the crutch of the smaller branchlets and the shoots die, turning a conspicuous yellow but not falling off immediately. In the leading shoot in the tree-top, a tunnel is made right up the centre.

Direct control of the beetle in the shoots is not possible, but it can be attacked in the breeding stage under the bark by cutting out all suppressed and sickly-looking cedars. Like many other forest pests we have found, this one has yet to be named.

The Scolytid mentioned above, which has the unusual habit of boring into doors, floorboards, and so on, is very similar to the Cypress Bark Borer and, like it, exceedingly minute. There is little to say about it except that it has so far been found only in old, seasoned podo. Control methods are the same as for the true Furniture Beetles next to be described. It should be mentioned that the Bark Borers (Scolytidæ) have single-clubbed antennae like *Platypus* (Fig. 8). This is in order, for *Platypus* belongs to a sub-family of the Scolytidæ known as the Platypodinæ, although its damage to timber is in quite a different category. This illustrates what was said in the introduction, that the classification best suited to this account is based on types of damage, rather than on families.

The Furniture Beetles (Anobiidæ)

These are the Death-watch Beetles common in English furniture and now pretty well cosmopolitan. Like the Bostrychids, they have antennæ terminated by a three-segmented club and the head is again hooded by the pro-thorax immediately behind it so that it is not visible from above. However, in the Furniture Beetles this pro-thorax has not the globular form so typical of the Bostrychids and it is commonly slightly concave on either side. The tarsal segments are too small a feature to be of diagnostic use to anyone with only a pocket lens. Fig. 3 illustrates a typical Furniture Beetle which may be compared with Fig. 6. They are small, hard, black or brown beetles and with them in infested wood one finds their larvæ, white, curved grubs with brown heads and a distinctly swollen fore-part, the body tapering backwards and terminating in a globular extremity. Their small thoracic legs (visible only with a powerful lens) distinguish them from Bark-beetle and *Platypus* larvæ which are legless.

Although sometimes boring in dead forest timber or living under the bark of dead trees, Anobiids are of economic importance principally on account of the damage they do to converted and seasoned wood, some genera (*Anobium* and *Xestobium*) being very injurious furniture borers. The common furniture beetle, fairly cosmopolitan and long established in Africa is *Anobium punctatum* De Geer (*Anobium striatum* Oliv., *Anobium domesticum* Geof.). It is dark brown and about 3/16th inch long. The wing-covers are furrowed from end to end. One year or sometimes more is required in England (possibly less in Africa) to complete the life-cycle of the beetle from the egg-stage to adult. The eggs, although sometimes laid in old exit holes, are usually deposited by the female in cracks in the timber and the grub, being extremely minute, enters by a quite invisible hole and, after pursuing an irregular course in an ever-widening tunnel as it grows larger, finally pupates close to the surface where it emerges later as a fully-formed flying beetle. It is evident then that it is of little use following the principle, advocated by so many, of squirting chemicals into these exit holes which appear in the timber and with which we are familiar. The problem of control of furniture borers in houses and timber yards is not always easy. In the latter case, impregnation or heat treatment is the rule, with houses little can be done beyond giving unpainted

woodwork a superficial coat of some liquid deterrent. This will not penetrate far but will soak into the minute crevices where future eggs may be laid and thus affect the newly-hatched grub whose life commences close beneath the surface. Nothing can be done to those borers deep in the wood when the timbers are part of the house or form some piece of furniture which we cannot dip wholesale. On the other hand, furniture borers do not, it must be remembered, actually breed in the substance of the timber, so that at the end of a year those already within will have emerged and the superficial treatment will prevent a re-entry of larvæ. A solution recommended for general purposes is one of paradichlorobenzene crystals dissolved in paraffin, one part to three, or orthodichlorobenzene which is already liquid, although both these are of a volatile nature and should be re-applied at intervals. Certain trade products which contain, in addition, copper salts both insoluble in water and at the same time non-volatile may be recommended particularly for timbers exposed to weather. Where light-coloured furniture has to be treated without the slightest stain, zinc chloride in water is sometimes used. The newer insecticides should also prove useful against furniture borers. D.D.T. at the rate of one ounce dissolved in a pint of warmed paraffin should prevent attack if painted over the timber and allowed to soak in. There is even the possibility that D.D.T. or Gammexane smoke-bombs, burned off in an enclosed building, might catch the insects during their flight period and prevent them egg-laying.

In the timber yard (failing kiln-seasoning and complete closed tank impregnation) the best method for preventing attack and killing off those borers already in the timber would be to dip in almost boiling water containing 1½ per cent boric acid. This should also be the cheapest method. If the timber be allowed to cool submerged in the liquid, the impregnation becomes quite deep.

Oval Hole Boring Insects

We have now to consider those insects making *oval holes* (Fig. 10). Of these there are two families, the *Cerambycidæ* and the *Buprestidæ*, rather similar in that they comprise typically large beetles, generally one-half to two inches long, whose grubs bore long, wandering tunnels and pack the wood dust (or frass as it is technically called) tightly behind them. When a piece of timber is split, exposing these tunnels, the frass will tend to keep its compact form even when prised out. Typically one would say that the Buprestid grub bored a flatter hole than the Cerambycid and also preferred the region under the bark to that deeper in the wood, but there are so many exceptions that we must take the two types of damage as the same and make our diagnosis after finding the beetle or grub. If these cannot be found we are little the worse off as (in the timber yard at all events) the treatment is the same in either case. The two families are described separately.

Longhorn Beetles (Cerambycidæ)

It is probably safe to say that, in the great order Coleoptera (Beetles), the family Cerambycidæ is more easily recognized than any other. In most cases the beetles tend to be large, sometimes very large, and a typical Longhorn (Fig. 11) might be described as follows:—Wing-covers long, straight-sided and rough-textured. Head, pro-thorax and abdomen very distinctly separated (Fig. 8). Antennæ many-jointed and exceedingly long, the segments themselves being elongate and distinct. Base of antenna closely embraced by the compound eye which is like a strongly curved sausage. The way in which the antenna is cupped by the eye gives us the name Cerambycidæ (*Cer*—a horn, *Ambyc*—a cup). Legs long and well developed with apparently four-segmented tarsi. In addition, the beetle would be prettily marked, perhaps metallic, even have a furry appearance and might alarm its captor by stridulating (squeaking) and biting his fingers.

Cerambycids are essentially wood-borers, attacking living and dead trees. In standing trees or felled logs the egg is laid in a bark crevice and the newly-hatched larva burrows under the bark during its early life and later bores down into the sap-wood, in some cases even in to the heart. The boring leaves traces which are plainly diagnostic (Fig. 12). On stripping the bark off the tree channels aimlessly wandering and at the same time widening are seen, the widening being due to the growing of the larva. These channels, as already mentioned, are tightly packed with sawdust-like frass and, after attaining their maximum width, terminate in a cleanly-made *oval* hole penetrating deeply into the wood. Eventually, after about a year in growing trees or several years in dry timber, the larva once more regains the surface and pupates close under the bark or even in it, the pupal chamber being tightly sealed with compacted wood dust sometimes

reinforced with a calcareous secretion so that the whole may be found under the bark like a somewhat flattened pigeon's egg with the pupa rattling about inside (Fig. 13).

The larva itself is characteristic in form, being a flat, whitish grub, the segments of the body produced above and below into warty protuberances with which it shoulders its way through the tunnels. As one would expect from such a means of progression, the true thoracic legs are small and frequently reduced to a mere vestige. The hard brown head, armed with powerful jaws, is half sunk into the enlarged thorax and from thence backward the body tapers to the tail. It is not a difficult larva to identify (Fig. 14).

As far as growing trees are concerned, the damage is greatest in the early larval stage, for it is then that the living cambium layer beneath the bark is destroyed, seriously affecting the metabolism of growth and, should the borings surround the trunk, eventually causing death. Once the larvæ have abandoned the sub-cortical feeding and invaded the interior, the life of the tree is menaced no further unless it be through a mechanical weakening of the trunk which is rarely the case. From the point of view of damage to the timber, on the other hand, it is obviously the later larval period that is of importance and this applies to felled logs as well as standing trees. Even converted timber made up into furniture may support these large borers, and the writer remembers an uneasy night spent in a wooden bedstead so heavily infested that the noise of these active larvæ resembled the gnawings of innumerable mice. The Longhorn pupa is quite easy to identify by the long, clearly-jointed antennæ lying curved or loosely coiled against its sides (Fig. 14). It is white or cream-coloured and is found, as already mentioned, near the surface of the timber in which it lies.

Control against Longhorn Borers is difficult, particularly against those which are content to pass their lives in dry, seasoned wood. Those in living timber are generally confined either to sickly trees or else have gained entrance through some artificial interference with a healthy tree's growth. An excellent example is the Cypress Longhorn Borer, *Caloclytus carinatus* Aur., which has caused a good deal of damage in cypress plantations which have suffered late, heavy pruning. In this case the borer is found in the vicinity of the large unoccluded branch scars and riddles the wood a little way above and below this point. The remedy is simple, avoid delayed prunings of large branches or, better still, avoid large branches by light, frequent prunings and judicious thinning. Fig. 15 shows a cross-section through an unoccluded branch scar.

Cerambycids in dry, seasoned wood and in which they have already gained some depth, require heat treatment in a kiln. Temperatures of 50–60° C. (about 120–140° F.) under steamy kiln conditions will kill the borer if time is allowed for the heat to penetrate. For example, one hour would be allowed for planks, six hours for baulks and about 12 hours for logs. Steam is injected into the kiln and provides both heat and humidity. Where the installation of a kiln is not possible, immersion in nearly boiling water is effective, again allowing time for penetration of the heat. As mentioned in connexion with other dry-wood borers this hot bath may contain $1\frac{1}{2}$ per cent boric acid, in which case the timber should be allowed to cool submerged in the solution to induce maximum penetration. Where no chemical is dissolved in the water the timber may be protected against further infestation by painting with a detterent solution of paradichlorobenzene in paraffin (one part to three respectively), D.D.T. in paraffin (one ounce to the pint) or with one of the many commercially prepared timber preservatives.

Jewel Beetles (Buprestidæ)

The Buprestids are essentially forest beetles, the larvæ of which do a great deal of damage as borers under the bark of trees. They are generally large and very easily recognized, a characteristic feature being their bright colour which may have a metallic sheen. In form (Fig. 16) the beetle has a gently waisted appearance towards the fore-end of the wing-covers and is tapered towards the posterior. Where this characteristic form is not sufficiently pronounced, the underside of the beetle may be examined when the first thoracic segment will be found to bear a backward projection immovably fitted into the segment immediately behind it. The antennæ are short for the size of the insect and are usually clearly serrated. There are five tarsal segments. The unmistakable larva (Fig. 16) has a cobra-like expansion of the prothorax, giving it the popular descriptive name of "Flat-head Borer". The legs are barely recognizable or even absent.

As would be expected from the curious shape of these grubs, the borings are oval or quite flat in section, the latter form being the com-

moner and well suited to the part of the tree in which they are found, that is immediately under the bark. These wandering tunnels constitute a great danger to the living tree since they interfere with the actively growing cambium layer and, should several tunnels coalesce on all sides of the stem, the tree is virtually ring-barked. Besides growing trees, freshly felled logs are attacked and form a breeding place for the beetles. Finally, there are Buprestids which bore deeply into the wood and are found in sawn logs in the mills. The grubs of these are more cylindrical in form, sometimes lack the very flat expansion of the prothorax and make oval rather than flattened tunnels. As far as treatment is concerned, the same methods should be applied as those for the Longhorn Borers already described. As a control method against those forest species working under the bark of living trees, little can be done beyond felling trees as traps and barking these some time later to expose the grubs, the fresh slash in a forest clearing being a great attraction to the insects.

REVIEW

ALL ABOUT "K.N.C.U." COFFEE, R. J. M. Swynnerton and A. L. B. Bennett, Moshi Native Coffee Board, P.O. Box 132, Moshi, Tanganyika, 1948. Sh. 5, 212 pages, including 20 pages of photographs and drawings.

This book has been written mainly for the 30,000 Chagga coffee growers who are members of the Kilimanjaro Native Co-operative Union. The text is in two languages, English and Kiswahili. The first seven chapters give a simple history of coffee, describe its value to the Chagga, and tell how the Co-operative is organized. Eleven chapters describe the cultivation of coffee, and cover a wide range from the propagation of cuttings to pruning, shading, harvesting, etc. Eight chapters describe pests and diseases and their control; two tell how coffee is prepared by the grower, and four describe the curing, grading and sale of the prepared beans. There are twenty pages of photographs and drawings which illustrate the text.

Although this book has been written for Africans and the instruction about cultivation, diseases, etc., applies especially to conditions on Kilimanjaro, yet there is no doubt that it would interest many European growers outside the Kilimanjaro area, for it incorporates the result of most of the research work on coffee which has been done in East Africa over the past fifteen years. In this respect it is particularly valuable for it is not easy to keep track of the published results of research when they are scattered through many journals.

J. G.

REVIEW

Soil Physics, By L. D. Baver (2nd Edition, 1948), pp. XIII and 398, 58 tables, 89 text-figures, including nine photographic plates. Price, Sh. 4/75; John Wiley & Sons, Inc., New York, and Chapmans & Hall, Ltd., London.

In the seven eventful years since the first edition of this book, it has not been easy for Colonial research workers to keep abreast of soil science developments in the U.S.A. In a new American textbook on soil physics, the East African reader thus seeks primarily for a detailed critical account of recent work. From this aspect Dr. Baver's new edition is rather disappointing. Although the text is designed to provide a basis for the studies of the agricultural student rather than a reference book for the research worker, the increasing importance of field techniques in soil physics would seem to merit more attention both to their practical and theoretical problems.

In the expanding tropical agriculture of the East African territories, urgent problems of soil moisture and soil structure require the application of the most modern methods of soil physics, and these subjects therefore command first attention in a new book. On soil moisture, there is brief description, but little critical discussion, of the several methods of measurement *in situ*. The promising thermal method, in the development of which the author took part, is carried little further than in the original paper of 1939. Buckingham's classical hypothesis of Capillary Potential is developed in great detail, and is perhaps over-fortified by further elementary analogies. In a detailed consideration of soil moisture conductivity it is surprising that no reference is made to the elegant mathematical treatment and promising field observations published by Childs of Cambridge.

In discussing the distribution of air and water in the soil, the author places a welcome emphasis on the volumetric expression of moisture-content as an improvement on the traditional gravimetric ratio. The penalty of thus introducing an additional source of experimental error into the measurement of soil moisture is pointed out, but is considered justified by the information gained.

Measurement of the retention of soil moisture in terms of the deficit in free energy of the water system, and the application of Schofield's pF scale, is described without involving the reader in mathematical deviations. The difficult theoretical problems of the relative parts played by the forces of osmosis and surface tension, in the relationships of plants to soils, might well have been set more clearly before the advanced student as a chart to his course amongst the somewhat confusing results of recent experimental approaches to the subject.

The chapters on soil structure and on soil air include extensive Russian and German work on these subjects and offer most profitable reading. The employment of microphotographs to illustrate the detailed treatment of soil structure is a most successful improvement. The electron microscope pictures of clay minerals and the micrographs illustrating pore space distribution in soils provide a mental stimulus to the study of the data. The micrograph of soil granules among the rootlets of grass is particularly striking, although the author emphasizes our lack of knowledge of the mechanism of the granulation process.

The final chapter, on run-off and soil erosion, stresses the impact effects of raindrops and the importance of planning agricultural programmes to avoid soil exposure when rains are expected. The discussion outlines valuable American work not readily available for reference here and raises many problems pertinent to East African conditions. The solutions are, in general, not yet reached, and Dr. Baver stresses the need for further experimental studies of the physical processes involved and the present lack of accepted standards of measurement for those processes.

A useful bibliography is grouped under the subject headings to follow each chapter, and both an author and a subject index are provided. The printing and binding are of the pleasing standards to which we are accustomed in current U.S.A. production.

H. C. P.